

BBC

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is going electric

Galaxy quest

How we discovered
the Milky Way

**How to
swat flies**

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10

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WELCOME



TELEPORTATION IS THE closest science comes to magic. The idea of transmitting something across space instantaneously sounds impossible. And while the notion of travelling Captain Kirk-style is undeniably far-fetched, teleportation is set to transform the world in ways I couldn't imagine until I'd read Brian Clegg's article. Find out for yourself on p41.

Another fictional character, Sherlock Holmes, would be proud of the scientific detective work behind efforts to understand the Milky Way. How did we

discover our Galaxy's spiral shape, and much else besides, when we're on the inside looking out? Author Stuart Clark explains on p94.

Back on Earth, Formula 1 is an environmentally unfriendly sport. But now there's an alternative – a rival series with electric racing cars is about to get underway, as Rob Banino reports on p58.

From sporting to scientific spectacles, you may have seen an explosion or two in chemistry lessons. But I wish TV presenter Dani Jiménez had been my teacher. His experiments make for dramatic photos – as you'll see on p49.

This month we also preview the new telescope that makes stargazing easier than ever (p86), and discover the best way to swat flies (p74).

Enjoy the issue,

Graham

Graham Southorn, Editor

PS Don't miss our October issue, on sale 18 September 2014



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THIS MONTH WE...



...visited Yellowstone National Park with the Samsung NX30, the winning camera from our Summer issue test. See our website to find out how well it captured bison, grizzlies, and Old Faithful.

...went to the UK launch of Google Glass

– potentially the most revolutionary gadget since the iPhone. Find out if the augmented reality specs live up to the hype with our review on p89.



...talked to James A. Levine about the perils of sitting down all day, which reminds us... time for a walk. Find a review of his book *Get Up!* on p106 and listen to the interview on our podcast.

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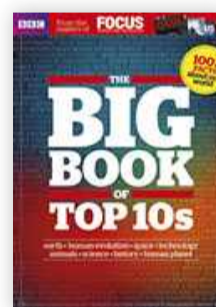
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APPEARING IN THIS ISSUE...



Brian Clegg

Take a look in the science section of your local bookshop and you're likely to find several accessible titles by Brian. He was the perfect choice to tackle the cutting-edge topic of teleportation (p41).



Timandra Harkness

Timandra's Science Burlesque at the 2013 Cheltenham Science Festival was the funniest stage show we've seen. In this issue she takes a wry look at why flies are so hard to kill (p74).



Dani Jiménez

Dani is a physicist who creates spectacular experiments in Barcelona for his programmes on Spanish TV. We explain the science behind his demonstrations on p50.



Helen Pilcher

Ever watched a film and wondered: 'Could that ever happen?' It's nothing new to Helen Pilcher, who tracks down experts to skewer *When I Go To Sleep* in Hollywood Science on p114.



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On p38, **David Hand** discusses the latest developments in the fields of 'big data' and statistics

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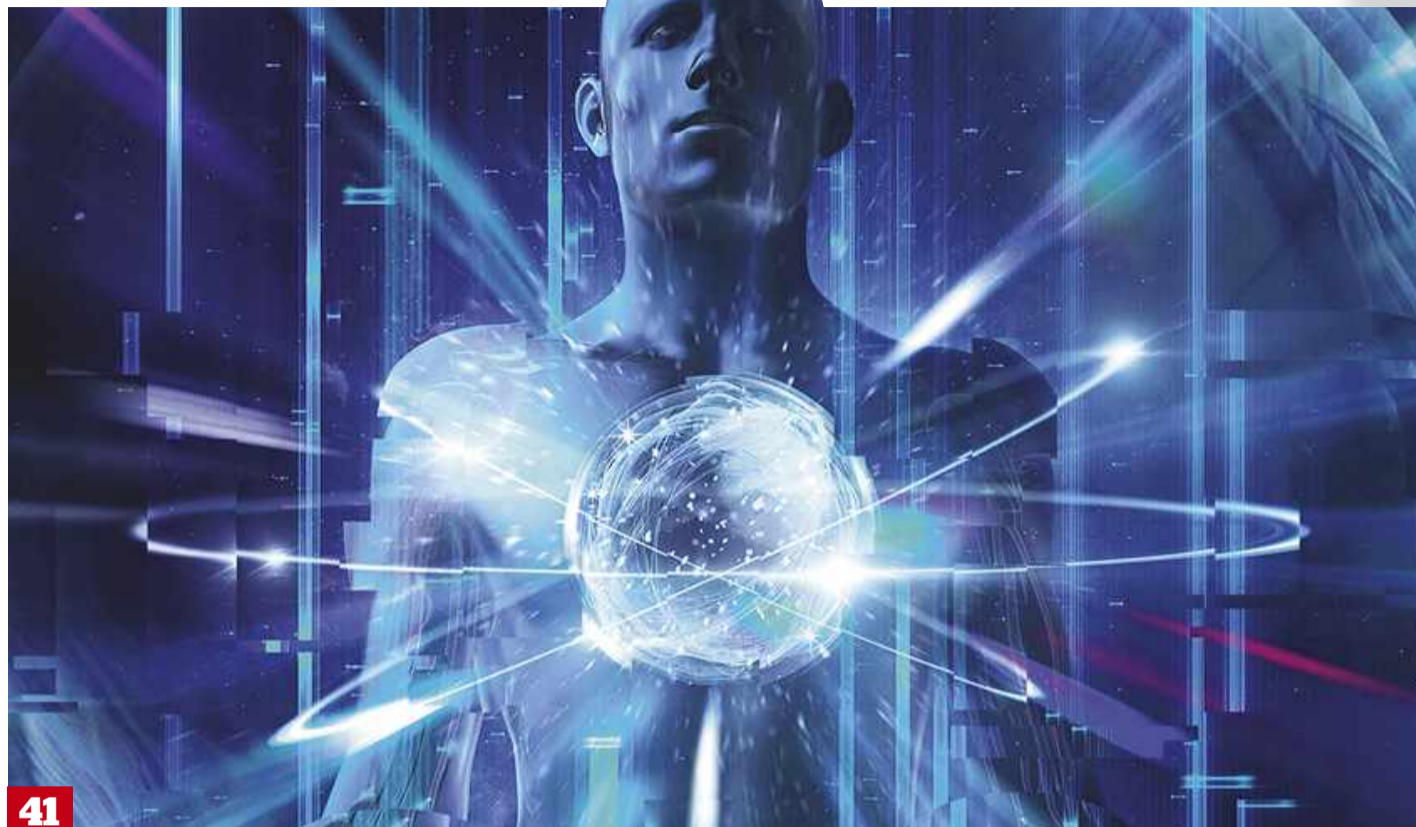
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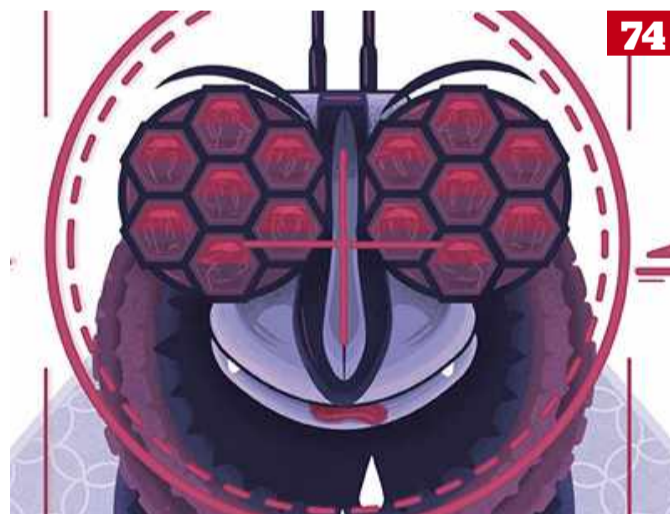
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Awe-inspiring images from the world of science

MegaPixel

Glowing underground

BRINGING TO MIND a night skyscape, these gently twinkling lights in the Waitomo Caves of Northern New Zealand are created by the collective bioluminescence of thousands of glow-worms, *Arachnocampa luminosa*.

Each glow-worm radiates a blue-green light created through the action of the enzyme luciferase on the compound luciferin in an organ similar to the human kidney. The worms fix themselves to the chamber ceiling and hang down long threads of sticky silk to ensnare small flying insects, such as midges and

mosquitoes, which are attracted towards the enticing glow.

After spending six to 12 months in their larval stage, the worms pupate into mouthless adult gnats that live for just a few days. "All the adults have to do is fly, and not very well at that, reproduce and die. All the eating and growing is done in the larval stage," says entomologist and BBC presenter George McGavin. "As adults, they put all their energy into egg production so the glowing ability is lost."

PHOTO: MARTIN RIETZE





MegaPixel

Deep space

THIS AQUANAUT WAS deployed to the deep sea in September 2013 as part of the Apollo 11 Under the Sea mission, which aimed to recreate Armstrong and Aldrin's famous 1969 moonwalk. Jean-François Clervoy, seen here off the coast of Marseille, wore a special space-diving suit hybrid designed by French diving experts Comex.

The submarine mission, led by the European Astronaut Centre in Germany, was a training exercise that simulated the gravity found on the Moon – which is one-sixth of what we feel here on Earth. “The Gandolfi suit is bulky, has limited motion, and requires some physical effort – just like actual space suits,” says Clervoy.

Clervoy planted the European flag and collected soil samples, using tools similar to those employed on the Moon by the Apollo 11 crew. The underwater expedition was a stepping-stone towards expanding European expertise in spacewalk simulations under partial gravity.

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Slow grower

THE ATACAMA DESERT in South America is peppered with odd, cushion-like plants known as the llareta, a spongy cousin of parsley. Despite the harsh weather conditions they have to endure, some of these plants are up to 3,000 years old.

Despite looking like a rock blanketed by moss, the plant has a tightly packed structure of branches, each adorned with clusters of

tiny leaves. The resulting plant is so strong that you could comfortably stand on top of it. However, this hardiness comes at a price: the plants are thought to grow just 1.5cm a year.

"I suspect that the llareta became so strong because of a combination of environmental stressors (cold at night and hot in the day) and grazing pressures," says Catherine

Kleier, a researcher from Regis University, Colorado, who studies the peculiar plant. "The plant is compact to trap heat and decaying leaves, but the more compact the plant, the more successfully it protects itself against grazing from the native viscacha, a long-tailed, rabbit-like rodent."

PHOTO: RACHEL SUSSMAN



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The fact that Newton was omitted from the 'Greatest Genius' nominations has baffled some readers

MESSAGE OF THE MONTH



Newton: the missing genius

All is not 'Feyn' with the 'Greatest Genius' vote (Summer, p46). I enjoyed the nominations feature in the Summer 2014 issue and I look forward to the outcome. However, I can't help but feel that more influential people have been missed out. Where was Newton, Dirac, Boltzmann, Schrödinger, Bohr, Pauli, Maxwell, Higgs?

It was my love of mechanics that got me in to physics in the first place, so my first reaction to the list was surprise when I discovered that Sir Isaac Newton was absent. So many branches of study and innovation came from the work Newton derived, which importantly includes the three laws of motion. Of course, like Jim Al-Khalili's self-stated obvious choice of Einstein, we can perhaps overlook the absence of Newton from the vote.

However on reflection, I'm sad to see that Richard Feynman wasn't included even though he's already been voted one of the top 10 physicists in the journal *Physics World*. While he was regrettably involved in the Manhattan Project, he made understanding the interaction of subatomic particles, through the use of Feynman diagrams, a simple task. He unlocked the world of quantum electrodynamics and in 1965 he jointly received a Nobel Prize in recognition of that. Furthermore, he was also the scientist who solved the mystery to the Challenger disaster in 1986 when he realised the 'o-ring' [rocket seal] had failed in cold weather. Feynman was an influential scientist and we are all still in the wake of his genius mind.

Phil Diggle

The greatest genius

Having read your article on the greatest genius, I was a little surprised that no one nominated Nikola Tesla. Undoubtedly the people picked are many of history's finest minds, but Tesla appears to be one of the more obvious, yet consistent, omissions. I'm not sure why he is so often forgotten when he truly is a father of the modern age. Many of your nominations were people with great tenacity who spent large amounts of time and effort conducting research but who lack the true spark of creativity of those such as Tesla and Leonardo da Vinci, who changed the world with their minds.

Will Hatton

How could Isaac Newton be left out? He is considered the greatest mathematician of all time (calculus etc). His *Principia* is widely regarded as the greatest scientific document of all time, not to mention his laws of motion, work on optics, and astronomy. Einstein regarded him as the bedrock of modern physics and made a glowing address at the 200th anniversary of his death. Your list cannot be complete without him, and he is British!

Ian Haxell

I wasn't impressed with a lot of the nominations for greatest genius in the last issue of *Focus*. Sure, many of them were worthy scientists, but at genius level, I have my doubts.

Furthermore, two real geniuses were left out. Michael Faraday must meet the definition of genius: he was self-taught, coming from a very humble background in an era when most scientists were of the gentleman amateur type, from a privileged background. His contributions to physics, and particularly to the fields of electricity and magnetism, were staggering and completely transformed our understanding of these phenomena. He was also responsible for introducing the idea of electric and magnetic fields into physics, and setting the stage for my second genius, James Clerk Maxwell.

Maxwell's contributions were wide-ranging, from the physics and theory of colour to theoretical thermodynamics. His greatest achievement was the merging of electricity and magnetism, into one phenomenon: electromagnetism, and



+ Write in and win!



The writer of next issue's 'Message of the Month' wins a Prestigio MultiCenter Internet TV box, worth £79.99. It upgrades any TV to give it smart functions, connecting via HDMI to play online video content in full HD quality. It'll also mirror your smartphone or tablet display on the big screen. See prestigio.com/multicenter

→ predicting that light is an electromagnetic wave.
Steve Jones, Bedford

Whilst acknowledging the published list is impressive – in my opinion Einstein stands way out ahead of the list – I would submit one man who receives practically no mention in any of these lists. James Clerk Maxwell defined, with four beautiful equations, the electromagnetic spectrum, which is the basis of all of today's communications and electronic advances. Readers wanting to learn more of this giant should read *The Man Who Changed Everything* by Basil Mahon.
Callum Grant, Glasgow

The main contenders (Einstein et al) in your survey of the greatest scientists seem impeccably worthy, if somewhat predictable. However, I did feel that the Ancient Greeks (especially Aristotle) deserved at least an honorable mention. They were not exactly scientists in the modern style, although they were not lacking an empirical streak, mathematical competence and deductive genius. After all, it was Ancient Greeks who set the ball rolling.

I also found the *Focus* team's selection of two relatively contemporary internet stars a little strange. I would be the last to deny that the internet has transformed modern life, but it is a technology, not something that has fundamentally changed our understanding of the world. If anyone connected to the internet deserves pride of place, it must surely be Tim Berners-Lee, who played a primary role in making the thing possible and has played an important role in sustaining its original values.

Michael Towsey

I was interested in your list of the greatest scientists and enjoyed the montage on the front cover. Most of the names are familiar, but it was good to be introduced to some unfamiliar great minds. I would have added Isaac Newton, for his contributions to motion, gravity, light, and calculus. My choice for the greatest would lie between Newton, Einstein, and Darwin – a matter of splitting hairs.

Roger Collinge, Holmfirth, West Yorkshire

In your article about the greatest genius you miss out one, whose invention was the basis for most modern means of communication. The electric telegraph was the basis for the telephone, television, radio, computers etc. In its own time it made a huge difference – for example, communication from London to Australia only took a few hours rather than months.

This was a far bigger quantum leap than the likes of the internet or Facebook. The inventor of the first practical telegraph, Baron Pavel Schilling, should surely have a place somewhere?

Richard Vallis

In his argument nominating Thomas Young as the Greatest Genius, Martyn Poliakoff stated that “‘Young’s modulus’, a measure of elasticity, explains the behaviour of springs and is the basis of everything from car suspension to the softness of your bed”. That unfortunate emphasis on the ‘springiness’ of stuff brought to my mind the legacy of Hooke (he of the elastic properties of springs) rather than that of Young (he of the stiffness properties of materials), which is a pity given that the strength of every engineered product derives from Young rather than Hooke. Perhaps what springs to mind from Mr Poliakoff’s argument compromises its strength.

David Rothwell, Thirsk

More headaches

The article on headaches made interesting reading (Summer, p60). However, in my experience sinus headaches are far from rare. Not only do they manifest themselves below eye level, but they can be

very severe in the frontal sinus area above the eyes.

Omitted was any reference to brain or other head tumours. Any patient with a headache will, at some time, wonder if such could be the cause, however unreasonable or unlikely.

Most do not cause headaches, as such, initially. Also there is an uncommon headache, temporal arteritis, occurring in the temple region caused by inflammation of the artery, which can lead to blindness if untreated.

Dr JM Foot



Oops!

- Apologies to Wrexham Science Festival for printing incorrect text in *Visit* (Summer, p103).
- The correct name for the yeast mentioned in July's '10 discoveries...' on p26 is *Aureobasidium pullulans*.
- In our Summer issue speaker review we tested the Braven BRV-X, which is waterproof up to 1m, not the BRV-1. Our review implied that Sonos only works with Spotify; it works with dozens of streaming services. The Beolit is now available for £429.

FOCUS

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Home cinema

Which sort of visual system do you go for? Projector and screen, or plasma, LCD or LED TV? 3D or non-3D?

Choosing a home cinema system is a potential minefield that must be negotiated with great care or safely avoided by letting experts guide you. If you want to end up with a system that, as a minimum, meets your expectations in terms of picture and sound quality, reading magazine product reviews and choosing the recommendations, five-star favourites or best buys can only ever be part of the answer at best. Looking for the cheapest price and having a system delivered to your door, even with a 'knowledgeable' friend to help set it up, is a well-trodden path to disappointment.

There is a bewildering choice of components on the market today and also different ways in which components can be installed and connected together. Which sort of visual system do you go for? Projector and screen, or plasma, LCD or LED TV? 3D or non-3D? Full 1080p capability is now the only sensible choice but the appropriate source components, such as a Blu-ray player, need to be part of the equation.

The sound performance of a system is also hugely important, even more so if you will be listening to music, or music DVD's, through the same system. If so, you need an amp that approaches the performance

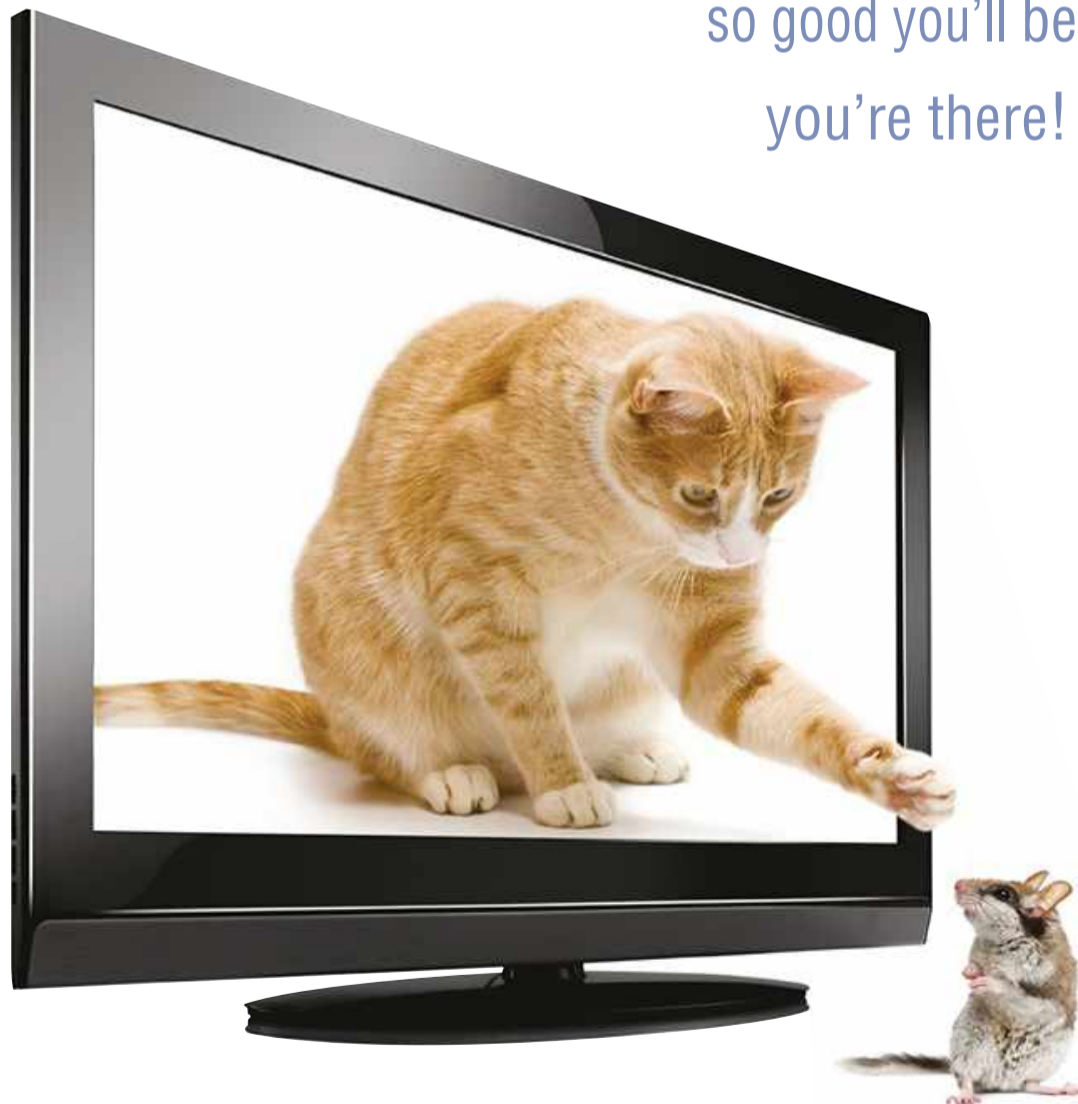
of a decent 2-channel hi-fi amp, which is not that easy to find. Having an amp with the right inputs for the best connectivity is essential but you will also need to decide on a 5.1 or 7.1 speaker system, passive or active sub and, crucially, where they will be sited for the best results. In short, it's complicated and very fertile ground for getting it wrong.

Achieving potential

To select a system, you could choose a collection of 'Best Buy' components in the hope that they will be a great combination. Maybe, but probably not. You could buy a pre-packaged all-in-one system from one manufacturer. This is almost certainly not the best route either, as you will miss out on enormous potential. From informal surveys conducted, it appears highly likely that the majority of home cinema systems

selected and installed on a DIY basis (that is without professional input) are performing at way below their optimum level. To compound matters, most are also ill-matched to the room in which they are installed and are, in reality, the wrong system. Without considerable knowledge or experience, high quality home cinema is not a suitable DIY activity. Our aim must be to buy a home cinema system that will provide an excellent picture quality plus an audio delivery that will match, or even better, the commercial cinema experience. It must be exciting, reliable and deliver true value for money.

“ Home cinema
so good you'll believe
you're there! ”



Selecting and installing home cinema on a DIY basis may leave the system performing at way below its optimum level.

Confused ?

What and Where to buy

To ensure a home cinema system is right for you, where do you start? Here's an important tip ...don't start with WHAT, start with WHERE. There's only one way to give yourself the best chance of getting it right first time, and that's through a specialist AV dealer. It's possible you have preconceived ideas that put you off visiting one. Although you would welcome the advice and guidance, you don't know the technical jargon. You don't want to be talked down to. Your friend has said they only sell expensive gear and they're not interested if you don't have a big budget. They're expensive. These are just myths.

Most specialist AV dealers are running their business because, above all, home cinema is their hobby. They spend a large portion of their time comparing systems to get the best possible results. They know the component combinations which don't gel together and, conversely, they know the combinations which give the best performance within a given price range. Very importantly, they know how to get a system working to its optimum. But they all also know the system must suit you.

Buying or being sold to

There are dealers around, web based or otherwise, who will sell you anything you are willing to pay for. They may be a bit cheaper but that's all they offer. Now there's a carefully selected group of long-established specialist dealers who are totally committed to putting the customer first. Their idea of 'selling' is to discuss your requirements, offer their advice, give you the best options, then play the systems for you and allow you to be the judge. You'll probably be surprised and, almost certainly, relieved to discover how easy it is to see and hear the differences between components and between systems. You'll be able to make a clear and informed decision about what to buy.

The story doesn't end there. These shops won't abandon you once you've put your hand in your pocket. They won't leave you to set up the system you've selected as best you can. They'll install it in your home, make sure it performs to its best, and ensure you're entirely happy with the way it works. Why? Because a high proportion of these dealers' custom comes through people who have bought from them before, either directly or by recommendation. It's vital to them to get it right for you.

Getting the best deal

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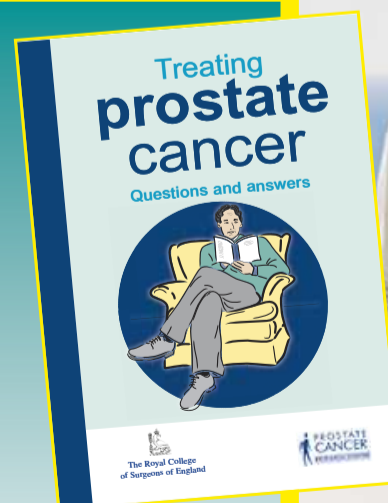
This booklet has two aims:

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DISCOVERIES

News and views from the world of science

EDITED BY
JASON GOODYER



p26

HOW BLACK CAN YOU GET?

UK scientists create Vantablack, the darkest ever material

p30



CAVES ON THE MOON

New images confirm that the Moon could have a complex cave network

p34



WALKING ON ALL FOURS

A rare condition may not have evolutionary origins after all

THE BIG STORY

80% OF LIGHT 'MISSING'

Astronomers have been baffled by a recent discovery, or lack thereof...

YOU'RE READY to leave the house, only to find that your keys have gone missing. It's a frustrating feeling, no doubt familiar to us

all. So, spare a thought for astronomers as the latest data from the Hubble Space Telescope shows that 80 per cent of light in the nearby Universe is unaccounted for. ➔

Light means we can witness the beauty of the Universe, but there could be plenty more that we're not seeing

PHOTO: GETTY

Installed on the Hubble Space Telescope, the Cosmic Origins Spectrograph found that 80 per cent of the light in the nearby Universe is missing



ANALYSIS

Dr Malcolm Fairbairn

Reader in Physics at King's College London



I THINK THIS finding is very unexpected. However, it is a very difficult area to study since the diffuse ultraviolet radiation that we think has been produced by various stars and quasars throughout the history of the Universe is very dim, and as such is very difficult to measure. Nevertheless, scientists are fairly certain that they know where this radiation comes from. So, for there to be too many ionised atoms for the known amount of ultraviolet radiation coming from these stars and quasars is very surprising. I don't think anyone knows what the reasons are for this discrepancy.

Getting reliable simulations of things in the Universe that contain dark matter and gas is always a tricky business because of the complicated physics of gas. Dark matter is actually easier to simulate because, unlike regular matter, you don't have to take into account pressure or radiation or stars. However, the authors argue that the regime where they perform these simulations should make the simulations reliable.

It is, however, a very exciting result. Discoveries like this, if they are taken seriously, usually lead to speculations about new science. For example, the authors themselves argue that this could be evidence for decaying or annihilating dark matter. I think that this is a possibility, but there are a lot of things about the astrophysics that need to be checked first.

➔ Observations made by the Cosmic Origins Spectrograph, a \$70 million instrument installed on Hubble, shows that there is a 400 per cent discrepancy in the light they were expecting to find. "It's as if you're in a big, brightly lit room, but you look around and see only a few 40-watt light bulbs," said the Carnegie Institution for Science's Juna Kollmeier. "Where is all that light coming from? It's missing from our census."

The research team analysed the tendrils of hydrogen that snake out through the vast reaches of empty space between galaxies. When hydrogen atoms are struck by high-energy ultraviolet light, they are transformed from neutral atoms to charged particles in a process known as ionisation. After analysing the data, the researchers found that there are far more hydrogen ions than can be explained by the known ultraviolet light in the Universe, which largely originates from objects called quasars – the energetic hearts of massive, distant galaxies.

"If we count up the known sources of ultraviolet ionising photons, we come up five times too short," said University of Colorado Boulder's Benjamin Oppenheimer. "We are missing 80 per cent of the ionising photons, so the question is where are they coming from? A fascinating possibility is that an exotic new source, not quasars or galaxies, is responsible."

The mismatch emerged from comparing supercomputer simulations of intergalactic gas to the most recent data from the Cosmic Origins Spectrograph. But it is only in the nearby, relatively well studied, area of the cosmos. When the telescope focuses on galaxies billions of light-years away, the numbers match.

"The simulations fit the data beautifully in the early Universe, and they fit the local data if we're allowed to assume that this extra light is really there," said Oppenheimer. "It's possible the simulations do not reflect reality. This would be a surprise, because intergalactic hydrogen is the component of the Universe that we understand the best."

TIMELINE

Our expanding knowledge of light

1864

James Clerk Maxwell publishes his famous equations of electromagnetism, explaining that light moves as a wave.



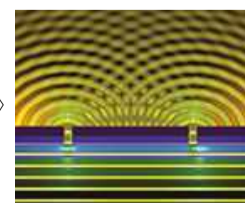
1905

Albert Einstein discovers the photoelectric effect that shows light can be thought of as discrete packets of energy, now known as photons.



1924

Louis de Broglie postulates that all matter has wave-like properties. The concept is now known as wave-particle duality.



1976

The Standard Model of particle physics is finalised, naming the photon as the force carrier, or boson, of the electromagnetic force.



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The fossil found in China of the new feathery dinosaur



PALAEONTOLOGY

Four-winged dinosaur found

MEET *CHANGYURAPTOR yangi*, a newly discovered 'four-winged' dinosaur found in China that lived 125 million years ago. Weighing 4kg and measuring 1.2m long, the dinosaur sports a full set of feathers covering its body, including 30cm-long tail feathers, the longest ever discovered.

Changyuraptor belongs to the *Microraptor* family, dinosaurs dubbed 'four-winged' due to the long feathers attached to their

legs that resemble a second set of wings.

After studying this plumage, the researchers have concluded that the dinosaurs were potentially capable of flying. If so, they would have used their tail feathers to provide additional balance and control.

"Numerous features that we have long associated with birds in fact evolved in dinosaurs long before the first birds arrived on the scene," says researcher



The wing-adorned form of *Changyuraptor yangi*

Alan Turner of Stony Brook University in New York. "This includes things such as hollow bones, nesting behaviour, feathers and possibly flight."

"Clearly far more evidence is needed to understand the nuances of dinosaur flight, but *Changyuraptor* is a leap in the right direction," added co-author Luis Chiappe.

1 MINUTE EXPERT

Vantablack



What's that? A newly launched inky-black soft drink perhaps?

Nope. It's the blackest material ever made.



OK then. Is it blacker than the Disaster Area stunt ship in Douglas Adams's *The Restaurant At The End Of The Universe*?
Yep. You got it.



Amazing. So what is it exactly?
It's a material made from carbon

nanotubes developed by Surrey NanoSystems, a company based in Newhaven. Its name comes from the fact that it is made from 'Vertically Aligned NanoTube Arrays'. It will be used in sensitive imaging systems, such as deep-space telescopes.



So how black is it?
It's so dark that it absorbs 99.965 per

cent of all light falling on it; a world record.



Stare into the abyss: Vantablack

Can science prevent another Dust Bowl?

DAVID SHUKMAN

The science that matters



One of the monitoring stations that form a network across Oklahoma



CAN YOU IMAGINE living somewhere that can face the deep freeze of a polar vortex, the savagery of a tornado and the crippled harvests of a punishing drought in the space of a year? That place is Oklahoma, a state in the heart of the US that endures more than its fair share of violent extremes. This year has seen dust storms severe enough to ruin crops and close highways.

It was because of dust that Oklahoma forced itself onto the national consciousness back in the 1930s. The land had become so parched that great clouds of the stuff reached all the way to Washington. This was the environmental nightmare of the Dust Bowl, immortalised by John Steinbeck in his classic novel *The Grapes Of Wrath*, and the government was forced to respond.

The first challenge was to feed the destitute. But next came the effort to improve farming practices. In an early application of agricultural science, the farmers were taught not to plough their fields – which exposes bare land to the wind – but instead to leave the stalks and roots of any crops in the ground. This would keep a lid on the soils to stop them being blown into the air.

More recently, everyone has had more warning of trouble. At 120 locations across the state, automatic monitoring stations provide data every five minutes about everything from rainfall to soil moisture. The university teams that run the system describe it as the longest running and densest network of its kind.

Irrigation is another answer, but the water level in the major aquifer is falling because of overuse and the supply is either inaccessible or expensive. New varieties of wheat are being tested for tolerance to drought, but the development process is slow.

The past three-and-half years have seen rainfall that is less than half the average. I asked one 101-year-old survivor of the Dust Bowl, Millard Fowler, if he feared the conditions of the 1930s might return. “They already have,” he said. The situation is not nearly as severe as it was back then – the dust storms are smaller and they last hours rather than days. But although scientific progress can significantly minimise the risks, it cannot completely eliminate them.

DAVID SHUKMAN is the BBC's Science Editor. @davidshukmanbbc

THEY DID WHAT?!

Researchers record the grumblings of seahorses

What did they do?

Brazilian zoologists fitted a sound recording hydrophone to an aquarium tank to monitor the noises emitted as seahorses

feed, attract a mate and are handled by humans.

What did they find?

The miniature fish happily click away during feeding, and this clicking intensifies when two engage in courtship activity. However, if a researcher tried to hold a seahorse near the hydrophone, the animal let out an angry sounding growl.



So, what's the seahorses' problem?

The scientists suspect the irate growling, which is accompanied by powerful body vibrations, are deployed as a last chance escape mechanism in the wild. “Seahorses are frequently grabbed and held by predators, such as frogfish, before being swallowed,” they explained.

10 DISCOVERIES THAT



Ants have been shown to help rocks suck up CO₂

Ants to help in climate change battle

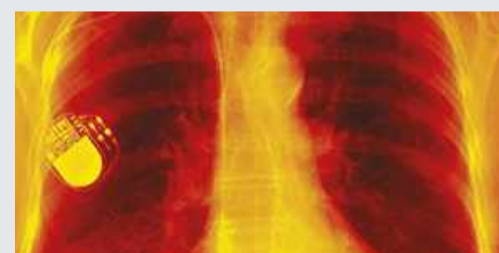
THOUGH MOST RENOWNED for their unerring ability to ruin picnics, it seems ants may prove to be vital allies in the fight against climate change. Rocks containing calcium and magnesium naturally absorb the greenhouse gas carbon dioxide as they break down, locking CO₂ into calcium

carbonate. Ronald Dorn of Arizona State University has found that ants increase the amount of calcium carbonate by 300 times, locking up more CO₂. If the process can be further studied and enhanced, it may be a viable means of geo-engineering the capture of carbon dioxide.

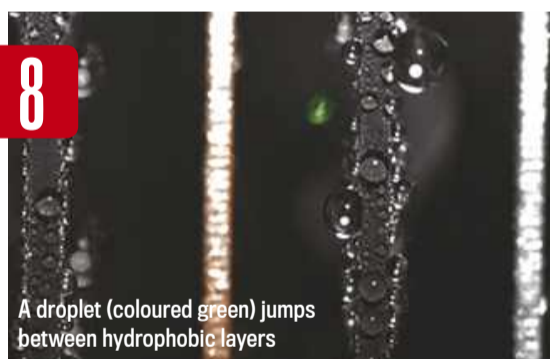
9 Biological pacemakers

INNOVATIVE GENE THERAPY techniques could potentially replace the need for electronic pacemakers.

Researchers in LA injected pigs suffering from heart block, a condition in which the electrical pulses controlling the heartbeat are disrupted, with a gene called TBX18. After 24 hours, regular heart cells began changing into specialised cells that keep the heart beating, they say.



Gene therapy could spell the end of the pacemaker



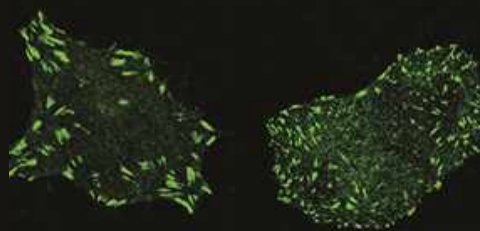
A droplet (coloured green) jumps between hydrophobic layers

Electricity from water

FROM COOKING AND cleaning to keeping us hydrated, water is essential. But now, scientists have found another potential use for the wet stuff: generating electricity in gadgets. Last year, MIT researchers found that water droplets gain electric charge when they 'jump' away from superhydrophobic surfaces – materials designed to repel water. By layering together many sheets of material, the team has produced a device that could potentially be used to charge small electronic devices such as mobile phones.

7 Cancer-halting gene found

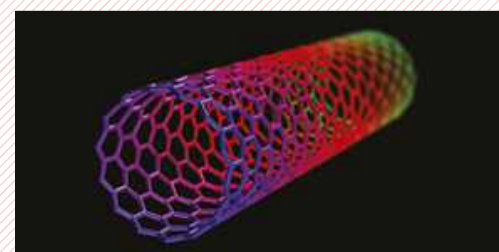
EIGHTY PER CENT of patients diagnosed with lung cancer die within five years. Now, researchers have found a gene that can halt the movement of cancer from the lungs to other body parts. The research could lead to more effective treatments. The team found that 'turning on' the gene DIXDC1 reduces the cancer's tendency to spread.



The bright green areas in these two cancer cells anchor them in place. With the gene DIXDC1 on, these areas are larger and stickier (left) than when it's off (right)

6 Nanotubes used to make hydrogen

WITH FOSSIL FUELS possibly running out by the end of the century, the search for new energy sources is gathering pace. Now, a team at Rutgers University has developed a low-cost method for producing clean-burning hydrogen fuel. The technology uses carbon nanotubes as a catalyst to create hydrogen and oxygen from water using electrolysis. The fuel could be used to power cars.



Carbon nanotubes could make hydrogen fuel viable

WILL SHAPE THE FUTURE

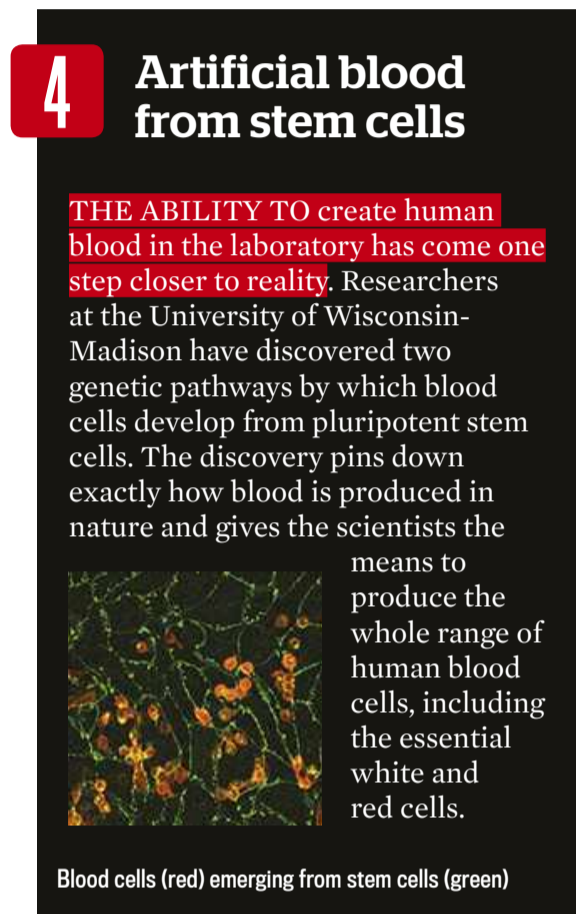


The nematode worms were unable to get plastered

5

Immunity to alcohol

EVER WOKEN UP regretting the previous night's overindulgence? Read on. Neuroscientists at the University of Texas have created 'mutant' worms that don't get intoxicated by alcohol, a discovery that may help those struggling with addiction and withdrawal. The team implanted a molecule into nematode worms that's responsible for binding to alcohol and triggering drunken behaviour in humans. They found the worms did not get drunk regardless of how much alcohol they consumed.



Blood cells (red) emerging from stem cells (green)

4

Artificial blood from stem cells

THE ABILITY TO create human blood in the laboratory has come one step closer to reality.

Researchers at the University of Wisconsin-Madison have discovered two genetic pathways by which blood cells develop from pluripotent stem cells. The discovery pins down exactly how blood is produced in nature and gives the scientists the

means to produce the whole range of human blood cells, including the essential white and red cells.

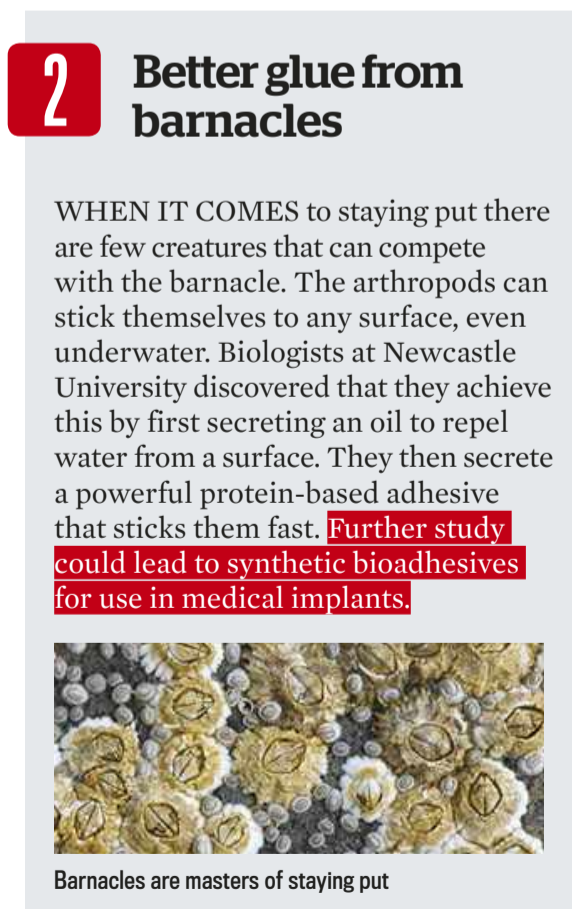


3

Liquid hard drive

NEXT TIME YOU see a glass of liquid next to someone's laptop think twice before taking a swig. You may be downing important documents or even their holiday snaps. A team at the University of Michigan has created a hard drive that suspends nanoparticles in water in special arrangements to store data. The technology could potentially store a terabyte of data in just one tablespoon of liquid. The hope is that the technology could eventually be used in medical devices placed inside the body.

Your hard drive could be liquid-based in the future

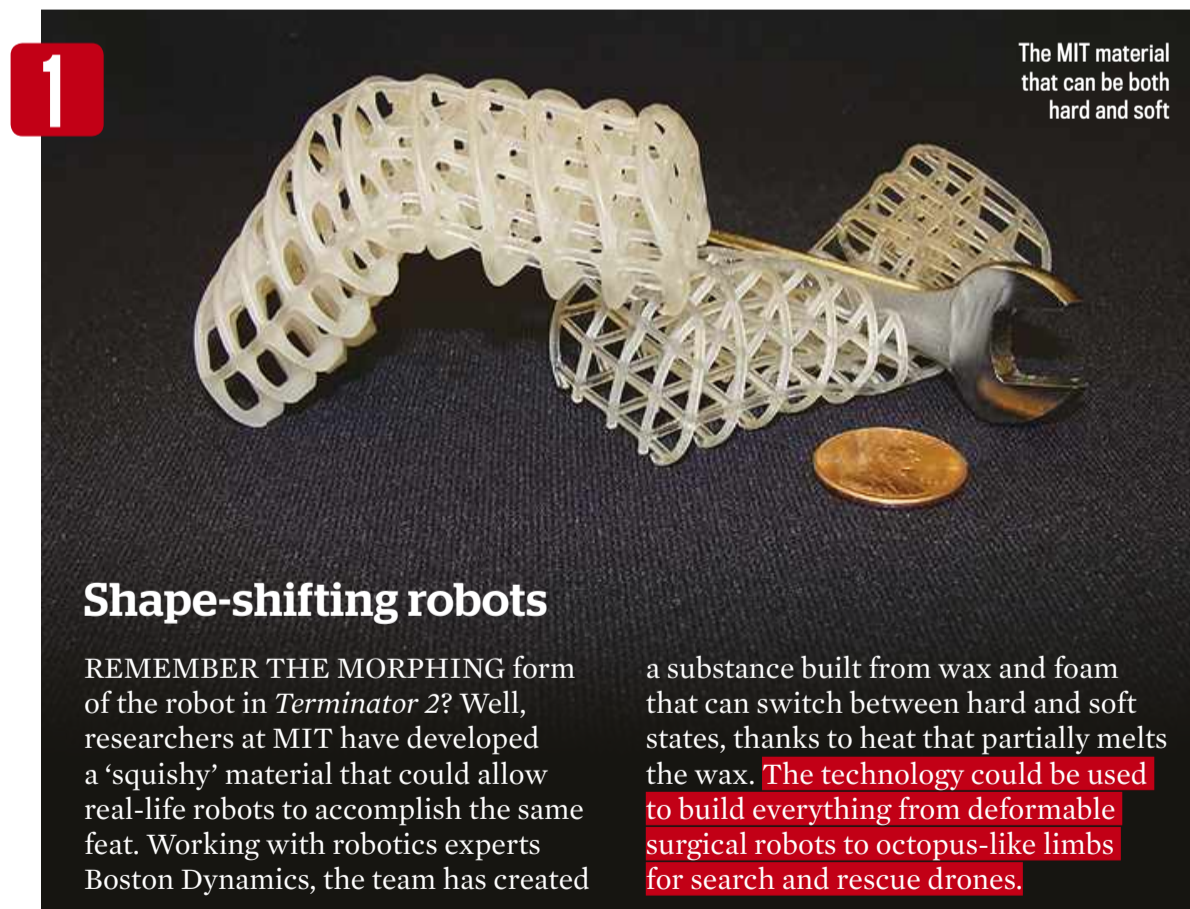


Barnacles are masters of staying put

2

Better glue from barnacles

WHEN IT COMES to staying put there are few creatures that can compete with the barnacle. The arthropods can stick themselves to any surface, even underwater. Biologists at Newcastle University discovered that they achieve this by first secreting an oil to repel water from a surface. They then secrete a powerful protein-based adhesive that sticks them fast. Further study could lead to synthetic bioadhesives for use in medical implants.



The MIT material that can be both hard and soft

1

Shape-shifting robots

REMEMBER THE MORPHING form of the robot in *Terminator 2*? Well, researchers at MIT have developed a 'squishy' material that could allow real-life robots to accomplish the same feat. Working with robotics experts Boston Dynamics, the team has created

a substance built from wax and foam that can switch between hard and soft states, thanks to heat that partially melts the wax. The technology could be used to build everything from deformable surgical robots to octopus-like limbs for search and rescue drones.

ASTRONOMY

Lunar tunnels confirmed

IT MAY NOT be made of cheese but the Moon is riddled with hundreds of swiss cheese-like holes, as this photos taken by NASA's Lunar Reconnaissance Orbiter shows.

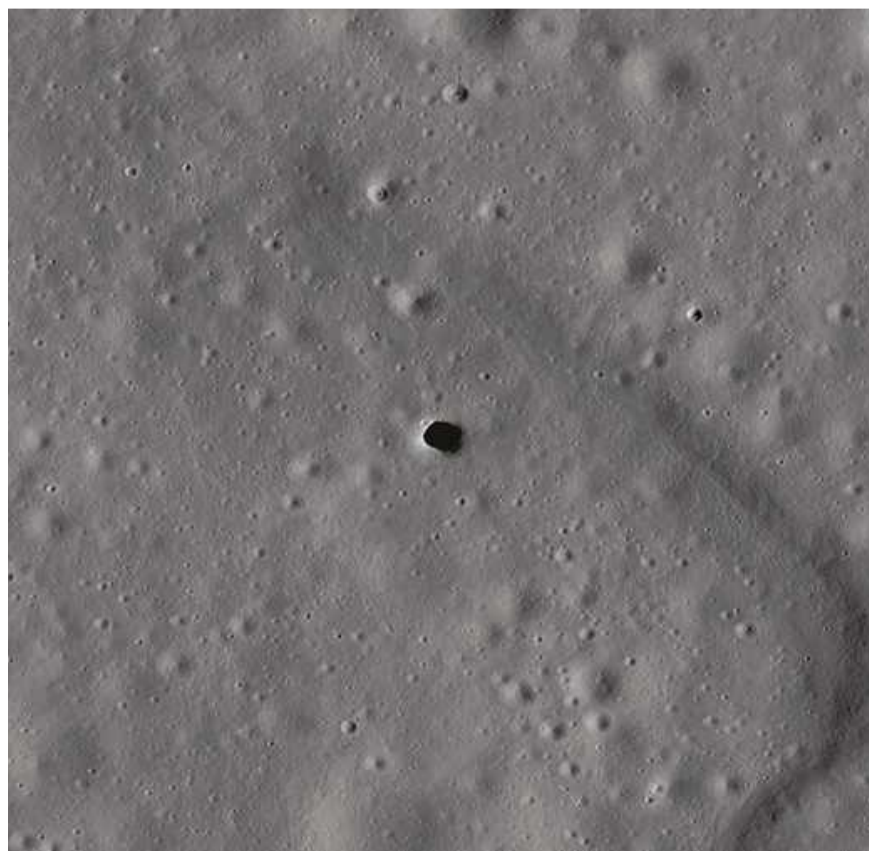
The enormous caverns littered throughout the lunar landscape were first photographed by Japan's Kaguya spacecraft last year, but now the LRO's high-resolution camera has taken further pictures that show the entrances to the caves and their surroundings in detail.

Researchers proposed the existence of a network of tunnels created by the action of molten lava rivers beneath the surface of the Moon in the 1960s. They based their theory on early orbital photographs that revealed hundreds of long, narrow channels called rilles winding across the vast lunar plains.

"It's exciting that we've now confirmed this idea," says

Mark Robinson of Arizona State University, principal investigator for the LRO camera. "The Kaguya and LRO photos prove that these caverns are skylights to lava tubes. So we know such tunnels can exist intact, at least in small segments, after several billion years. They could be entrances to a geologic wonderland."

If the tunnels are still open, they could someday provide visiting astronauts with protection from incoming meteoroids and the Moon's extreme temperatures that range from -150° to 100° , researchers say. "The tunnels offer a perfect radiation shield and a very benign thermal environment," says Robinson. "Once you get down to two metres under the surface of the Moon, the temperature remains fairly constant, probably around -30 to -40°C ."



This hole on the surface of the Moon could mark the entrance to underground caves

PHOTO: NASA/LRO



CLICK HERE

New websites, blogs and podcasts



CITIES AT NIGHT

www.citiesatnight.org

Astronauts have been taking images of Earth at night for over a decade. Cities At Night has collected those pictures and put them on a map. The site makes it clear just how much light pollution our cities are giving off, stopping

us seeing the night sky in its natural state. But you'll be forgiven for thinking that the cities look beautiful all lit up, too.



CONDOR WATCH

www.condorwatch.org

The California condor is critically endangered and lead poisoning is not helping the vulture's numbers. You can help by looking at photos of the birds taken by motion-activated cameras and identifying their tag number.

By tracking the location and behaviour of the birds, Condor Watch hopes to make scientists better at detecting early signs of the illness.



NAME EXOWORLDS

<http://nameexoworlds.org>

There's a list of 305 exoplanets here, and this is your chance to name one of them. It's an official project run by the International Astronomical Union and you'll have to register as a club or non-profit to take part

in the naming. But from next year anyone will be able to vote on the names. The results will be announced next summer.



NAUTILUS LIVE

www.nautiluslive.org

Indulge your inner marine biologist with this live webcam under the sea. The site gives plenty of information about which project is currently running. A new project starting 18 September will explore Kick 'em Jenny, the most active submarine volcano in the Caribbean Sea. With so much of the ocean still unexplored, you could see something totally new.



KELLY OAKES is a science journalist who tweets from @kahoakes



INSIDE SCIENCE

ROBERT MATTHEWS

Whether or not healthy people should be on statins isn't simply a matter of fact

THERE'S SOMETHING VERY cool about sorting out bitter disputes with a neat bit of logic. It worked for King Solomon when faced with two women both claiming to be the true mother of a boy. He offered to treat them fairly – by killing the kid and giving them both half. That instantly revealed the true mother, who pleaded that the boy be given to the impostor rather than killed.

Happily, we usually resolve scientific disputes in slightly less dramatic ways. If we're right, we'll be able to point at the hard evidence backing our case, while our opponents are reduced to huffing and puffing. And that's what elevates science above stuff like English Literature. It's because, as James Schlesinger, America's first energy secretary, once put it: "People are entitled to their own opinions, but not their own facts".

This pithy little maxim reared its head recently in the ongoing row over whether healthy people should take cholesterol-lowering statins. Many respected researchers argue that such widespread use of statins would prevent thousands of deaths through heart disease. Others reject it as the 'medicalisation' of otherwise healthy people, and say there's too high a risk of side effects.

Fortunately, as this is a long-standing scientific argument, there's no shortage of hard evidence. A recent analysis of studies involving a combined total of over 80,000 people suggests healthy people who take statins will indeed benefit by living longer. It also found that the best-known side effects of muscular pain and tiredness are experienced by those on the drugs – but also by those that aren't. In short, statins aren't to blame.

That's that, then; debate over. Well, not quite – because facts and opinions are often harder to separate than many scientists would have us believe. For a start, the benefit from statins is tiny: just a 0.5 per cent decrease in the risk of death. That's a worthwhile benefit on a national scale, as it translates into thousands of lives saved. But for any individual – not so much. Same facts; different conclusions. The same study found a small extra risk of diabetes among statin-takers. Still, most people would surely prefer diabetes to death, wouldn't they? Again, it depends whom you're asking. Recent research suggests healthy people will want a hefty benefit to compensate for any extra risk – and with statins, they won't get it.

The tabloids often like to interpret scientific journals in an alarmist way... be warned



“Healthy people will want a hefty benefit to compensate for any extra risk – and with statins, they won't get it”

Scientists dedicated to improving the nation's health clearly think the facts prove they're right about statin use. Yet those same facts look very different to Joe Public faced with deciding what to do. The fact is that in these sorts of debates, it's not just a straight fight between opinions and evidence. People make their decisions based on opinions about the evidence. Professor Sir Rory Collins of Oxford University, often portrayed as 'Cheerleader-in-Chief' for statins, knows all this. To his credit, he's made clear that patients and doctors are entitled to make up their own mind. But he still seems convinced 'the facts' are what win arguments.

I suspect that the scientific facts about statins may well count for nothing. That's because if anything new and 'controversial' is tried with huge numbers of people, you're guaranteed to get stories about bad reactions. And as the MMR vaccine debacle showed, just a handful of spurious cases are enough to set the tabloids off.

If they want to win the debate, the one fact Sir Rory and his colleagues should focus on is that a few anecdotes often count for more than 80,000 data-points. ■

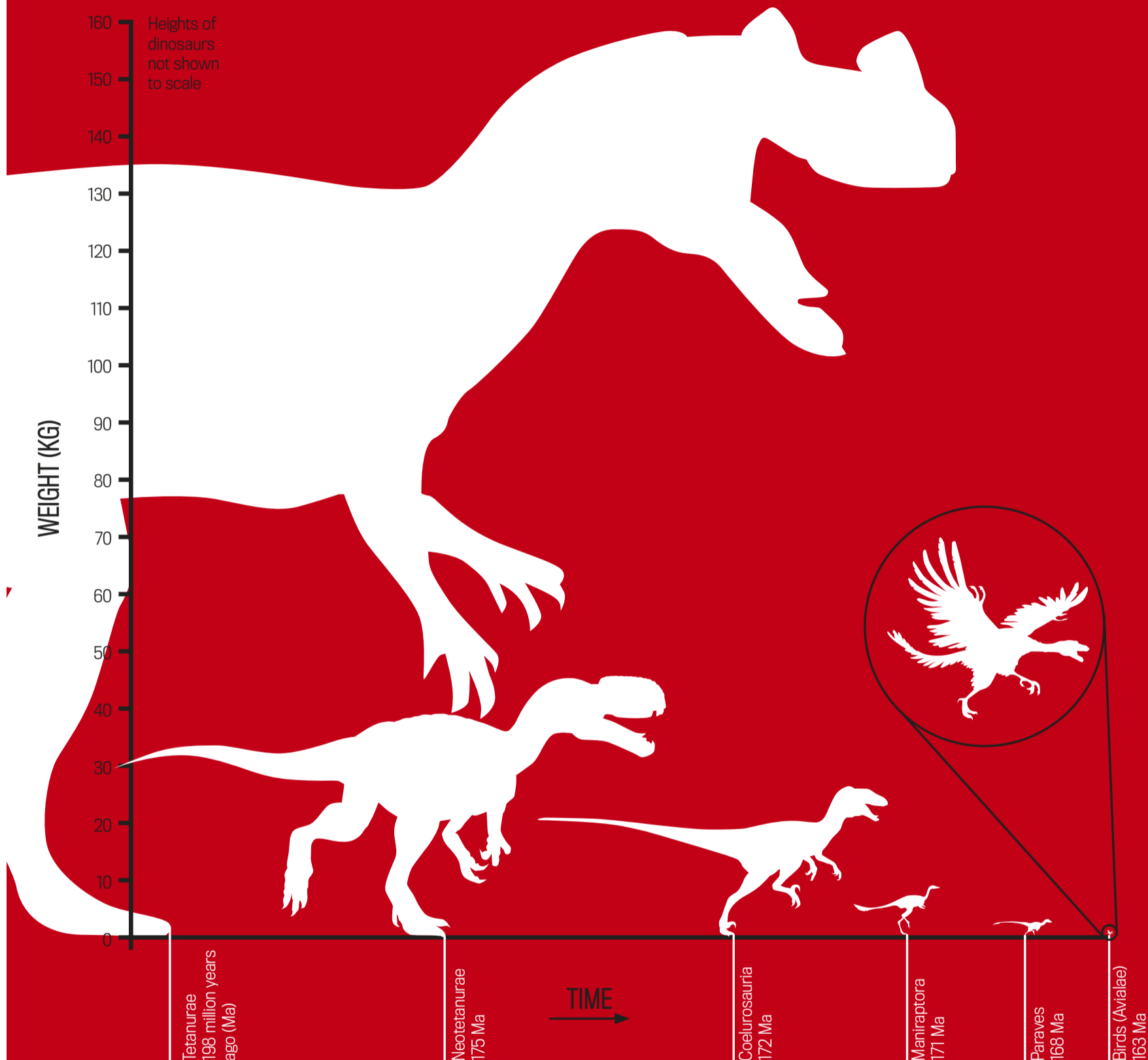
ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham



GRAPHIC SCIENCE

Seeing research differently

DINOSAURS' RAPID WEIGHT-LOSS



IT TURNS OUT size does matter. Huge meat-eating dinosaurs shrank over 50 million years to become modern birds, giving them an evolutionary advantage, researchers at the Universities of Southampton and Adelaide have found. Beginning around 200 million years ago, theropods, a family of hulking dinosaurs, decreased in average body mass 12 times from 162.2kg down to

0.8kg for *Archaeopteryx*, the earliest known bird.

The team analysed more than 1,500 anatomical characteristics of 120 different theropods using sophisticated modelling techniques. They used the resulting data to map out the changes in body size over time across different evolutionary paths. As well as shrinking, theropods also evolved new

adaptations, including feathers, wishbones and wings. They did this four times faster than other dinosaurs, giving them an advantage. "Being smaller in a land of giants, with rapidly evolving anatomical adaptations, provided these bird ancestors with new ecological opportunities, such as the ability to climb trees, glide and fly," says researcher Michael Lee.



EVERYDAY SCIENCE

HELEN CZERSKI

Trying to turn a red rose blue reveals the structural secrets of flowers

EVERY EVENING FOR the past week, I have found myself staring at white roses and willing them to turn blue. The roses have not been co-operating. Elegantly and stubbornly white, they laze in their bath of food dye, resisting its charms. It's been a frustrating few days.

It started because I was thinking about how plants move. It's slow and limited, but they can uncurl their leaves, open up their buds and some turn their flowers to face the sunlight. Yet they don't have muscles, or anything like them. Sometimes that movement happens because cells on one side grow faster than the other, but that can't explain a flower repeatedly opening during the day and closing at night. The real secret is hydraulics, and the key to that is water.

I'd confidently bought white carnations and lots of food dye. Flowers constantly lose water through their petals and leaves, but they balance the loss by taking up more through their stems. If you put food dye in the vase, they'll take up the dye as well, and the petals will change colour. Inside the stem of a flower there are two sets of tiny tubes, the xylem and the phloem. The xylem is the inner set, and it can carry water upwards because the tubes are incredibly narrow. As water evaporates from the petal, the tube supplying it is too tiny to take in a bubble of air at the top, so surface tension pulls the whole column of water up to fill the gap. If it didn't happen, we wouldn't have trees because there would be no way for water to reach the leaves at the top.

But it wasn't happening in my kitchen. After three days, my carnations were still very white and starting to wilt. Non-woody plants hold their shape through water pressure. Their cellulose cell walls are so strong that each cell can take in enough water to inflate it until it's really stiff, like a newly-pumped up football, and the plant can hold its shape. When the plant dries out, the cells lose water and deflate. Petals open and close by controlling their internal water pressure, making individual cells slightly bigger or smaller to change the plant's shape. But the cells in my carnations had lost their water, their strength, and their will to live. Not to be deterred, I bought more carnations, some roses and new colours of food dye.

While I was waiting for the next set to drink the rainbow, I looked at the scientific literature on why a thirsty flower might not take in water.

"You can see the vein structure of the rose's xylem beautifully, although the result is quite disturbing to look at"



Apparently bacteria can sometimes grow on the cut flower stem, clogging it up. And careless cutting can let bubbles into the base of the xylem, breaking the water chain to the top. I thought I'd been careful, but the second set turned a whiter shade of pale and keeled over. I asked a florist. "Oh, we don't use dye any more," he said, cheerfully selling me more roses and some chrysanthemums. "When we want to change the colour these days, we just spray them."

I fared much better with my second attempt. The chrysanthemums are still boringly pallid, but I have one rose with pale blue highlights (if you squint), two nauseous-looking green roses, and one that looks like it's a giant bloodshot eye. That's the one I put in the pink dye, and you can see the vein structure of the rose's xylem beautifully, although the result is quite disturbing to look at.

I am pretty disappointed that I couldn't coax a rose to turn blue. But next time I see a flower, I'll be able to imagine all those tiny internal hydraulic systems holding it up and keeping it alive. ■

DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter who appears regularly on *Dara O Briain's Science Club*



PATENTLY OBVIOUS with James Lloyd

Inventions and discoveries that will change the world



Cooler shaker

WE ALREADY HARNESS renewable energy from the Sun, the wind, the waves, and even the ground. Soon, we may need to add music to that list as well. SPARK is a handheld percussion shaker that converts its movements into electricity. Developed by Sudha Kheterpal, percussionist in the electronica band Faithless, the instrument contains a magnet that moves back and forth through a coil of copper wire as it's shaken. This induces a current in the wire, charging up a battery that can be used to power a plug-in light or charge a phone.

The idea is that SPARK will give people access to green energy in places without electricity. A prototype has already been tested in Kenya, where 75 per cent of the population lives off-grid. Currently, 12 minutes of shaking provides an hour of light – enough to help someone find their way home after dark or read a bedtime story.

Patent pending

Place your password

IF YOU'RE ANYTHING like us, you'll have so many online passwords that you forget them quicker than a goldfish with amnesia. To help us commit them to memory, computer scientist Ziyad Al-Salloum has developed a new kind of password based on geographical information rather than strings of letters and numbers. You simply draw a box around your place of choice on a map, whether that be a favourite holiday spot, the place of your first kiss, or another location close to your heart.

Patent application number:
GB 2509314

Handbag, lumos maxima!

IT'S ALWAYS THE same: you open your bag to find your car keys, only to grasp a handful of sweet wrappers and a manky old tissue. Thank heavens, then, for a nifty bag-lighting device that's been designed by two inventors in Nottingham. Their spherical light rolls around your bag as you walk, using its kinetic energy to charge a battery. A brisk tap to the bottom of the bag triggers a switch on the gadget, illuminating your worldly possessions.

Patent application number:
GB 2509324

BIOLOGY

Do these humans walk like apes?



The Ulas family were found walking on all fours in a remote part of Turkey

WHEN THEY WERE first discovered in a remote corner of Turkey in 2005, the Ulas family baffled researchers because they walked on all fours like gorillas. Initially it was thought that this was due to a backward evolutionary step that left the family with an unusual ape-like gait. The condition was dubbed Uner Tan syndrome (UTS) after the Turkish evolutionary biologist who proposed it.

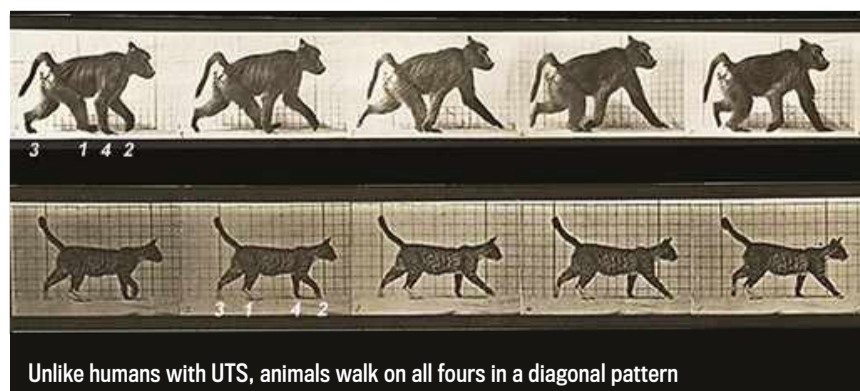
However, according to new research by Liza Shapiro, an anthropologist at The University of Texas at Austin, people with UTS do not walk in the diagonal pattern characteristic of non-human primates. "Although it's unusual that humans with UTS habitually walk on four limbs, this form of quadrupedalism resembles that of a healthy adult human if they were to move in this way," Shapiro says. "As we have shown, quadrupedalism in healthy adults or those with

a physical disability can be explained using biomechanical principles rather than evolutionary assumptions."

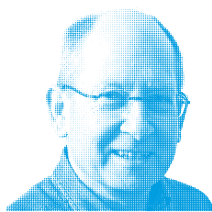
Shapiro and her team analysed 518 quadrupedal walking strides from several videos of people with various forms of UTS, including footage from the BBC Two documentary *The Family That Walks On All Fours*.

They compared these gaits to previous studies of the walking patterns of healthy adults who were asked to move around a laboratory on all fours. They found that 98 per cent of the people walked in lateral sequences, meaning they placed a foot down and then a hand on the same side, and then moved in the same sequence on the other side.

Apes and other non-human primates, however, walk in a diagonal sequence, in which they put down a foot on one side and then a hand on the other side, continuing that pattern as they move along.



Unlike humans with UTS, animals walk on all fours in a diagonal pattern



INTO THE FUTURE

STEPHEN BAXTER

If we colonise the Solar System, the speed of light will be what forms new nations

THIS MONTH A new permanent exhibition opens at the Science Museum on the 'Information Age' – I have contributed to an accompanying volume. What's striking about the modern information age is an abiding need for old-fashioned personal encounters, with the deep communication and level of trust they bring. World figures frequently meet in summits to handle ongoing issues such as economic or climatic pressures, or crises such as have unfolded in Syria and the Ukraine this year.

One hundred years on, our studies of the causes of the First World War confirm the importance of personal contact. Even in 1914 the world's capitals had telecommunications in the form of the telegraph and telephone. But despite many of the principal players being related – the German Kaiser, British King and Russian Tsar were cousins – without personal meetings, without seeing each others' faces, the members of the various governments were left guessing at each others' intentions. The resulting misunderstandings proved disastrous.

Today it takes only a third of a second for a radio signal to bounce off a geosynchronous communications satellite and be reflected back to Earth – and even less for a signal to be transmitted along a ground-based fibre-optic cable. Our leaders can now meet in cyberspace with time delays of only a fraction of a second – and they can see each others' faces, although they clearly still feel the need to meet at summits.

We can imagine Earth itself growing ever more united through communications technology, but what if we build an interplanetary society? It takes just a second for a radio signal to travel from Moon to the Earth. In the Apollo era, the short time lags did not prevent mission controllers at Houston from holding reasonably comfortable conversations with astronauts on the Moon. So the Moon, and similarly near-Earth space stations, could stay bound to a unified terrestrial society.

But the closest Mars has ever been to Earth is about 56,000,000km, which imposes a one-way communications time lag of more than three minutes. Will this always be too long for an authentic human conversation? Perhaps a new 'nation' of Mars and its moons will emerge, forever divided psychologically from Earth-Moon by the barrier of light-speed delays. Jupiter and its moons are never less than some 35 minutes' communications delay from Earth – but it takes only 13 seconds

"A new 'nation' of Mars and its moons will emerge, forever divided psychologically from Earth-Moon"



Communication across the vastness of space would make it difficult for nations to stay in touch

for a signal to span the orbits of the four principal moons. Saturn and its moons may form a similar system, unified but separated from the Earth.

What of the asteroids? The bodies in the main belt, between Mars and Jupiter, are scattered around an orbit with a radius of over 400,000,000km. Most of them will always be separated from each other by several light-minutes of delay. There are more coherent groups, such as the Trojans, which collect in points of gravitational stability in Jupiter's orbit – but even these span hundreds of millions of kilometres. In terms of direct human contact, individual asteroids may be forever isolated from each other.

Perhaps we will see the emergence of 'nations' in interplanetary space, islands of colonisation divided by light-speed limits: Earth-Moon, Mars, the Jupiter and Saturn moon systems. It's strange to think that basic limitations of our human nature, coupled with the light-speed barrier, might impose a

geography on the entire Solar System. But it is to be hoped that these limitations of communication never let us sleepwalk into a war even more calamitous than that of a century ago. ■

STEPHEN BAXTER is a science fiction writer whose books include *The Science Of Avatar* and the *Northland* series



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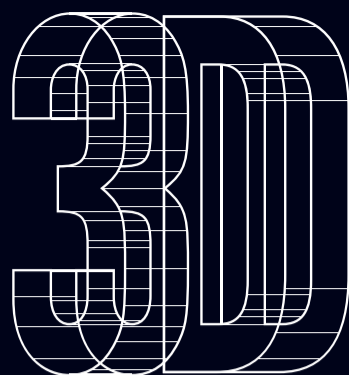


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ART ARCHITECTURE BUSINESS CONFERENCE DESIGN FASHION FOOD INDUSTRY MUSIC PUBLIC TECHNOLOGY

A futuristic illustration of a man with a glowing sphere in his chest, surrounded by digital light effects. The man is bald and has a serious expression. The sphere is made of many small, glowing points connected by lines, resembling a molecular or atomic structure. The background is dark blue with many vertical and diagonal lines of light, some of which are blurred, creating a sense of motion and depth. The overall color palette is dominated by blues and purples, with bright yellow and white highlights from the light effects and the sphere.

THE COMING AGE OF TELEPORTATION

A staple of science fiction, teleportation is now real and being developed the world over, though not in ways you'd probably imagine. Brian Clegg reveals all

THE WORD ‘TELEPORTATION’ inevitably conjures up visions of sci-fi wonders like *Star Trek* transporters, *Doctor Who* transmats and mad inventors suffering for their science in movies like *The Fly*. The concept seems as far fetched as faster-than-light travel and time machines. But teleportation is gradually becoming a reality on a tiny scale. Quantum computers, the big hope for a leap forward in computing technology, rely on its principles to work.

The theory behind teleportation, more accurately termed quantum teleportation, emerged from a long-running argument between Albert Einstein and Niels Bohr. Einstein laid the foundations of quantum theory and was a strong supporter of it until randomness came on the scene. He changed tack when the new generation of physicists working in the field discovered that quantum particles were governed by probability. He hated this, remarking ‘The theory says a lot, but does not really bring us any closer to the secret of the ‘old one’. I, at any rate, am convinced that He is not playing at dice.’ As a result, for years Einstein taunted Bohr with challenges on the validity of quantum physics.

The last and greatest of these attacks came in 1935 with a paper co-authored by Einstein and two colleagues, Podolsky and Rosen, known by their initials EPR. This paper demonstrated that either quantum theory was wrong or that it made the apparently impossible, possible. EPR showed that it should be possible

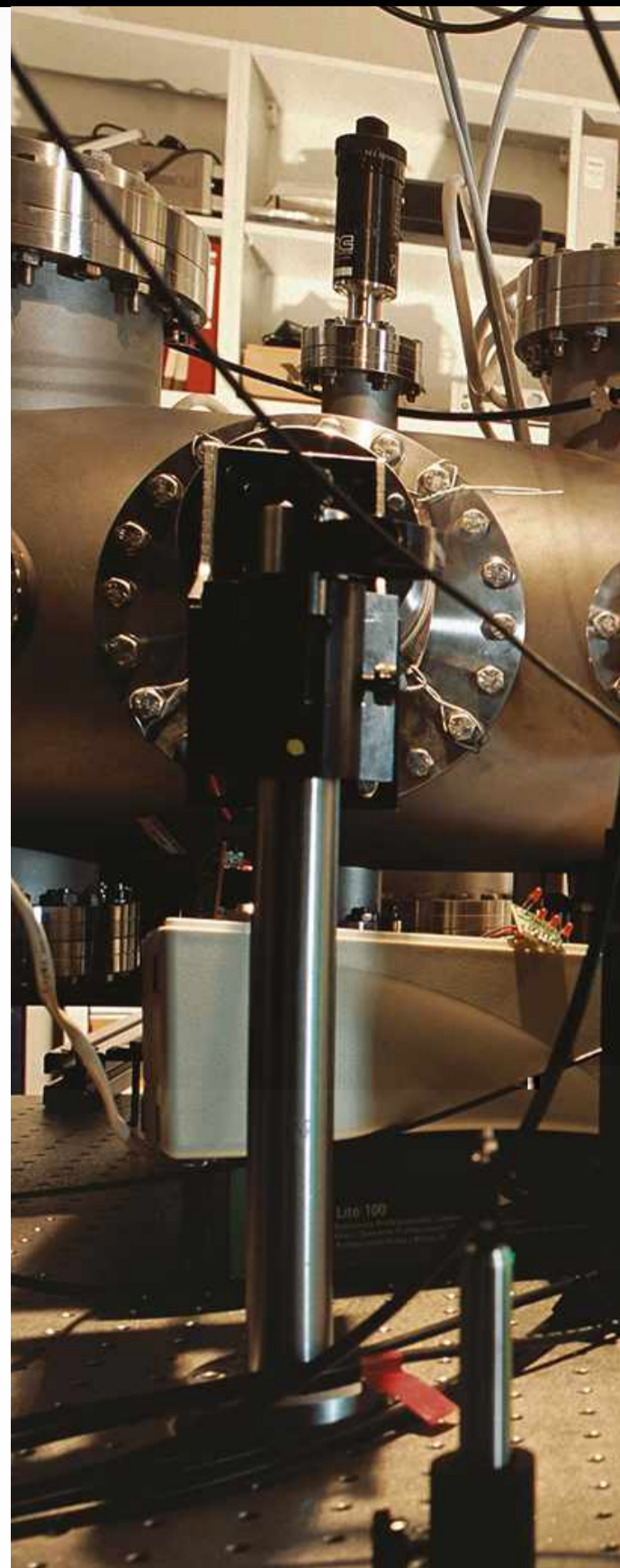
“Einstein thought he had found a chink in the armour of quantum theory”

to create a pair of quantum particles in a state known as entanglement. These particles could be separated to opposite sides of the Universe and a change in one would immediately be reflected in the other. Somehow they could communicate instantaneously. Einstein thought he had found a chink in the armour of quantum theory. But instead he had highlighted one of the most remarkable capabilities of quantum particles. Moreover, experiments have repeatedly shown that entanglement does, in fact, exist.

To the layman, it sounds as if entanglement could be used to send instantaneous messages from one side of the Universe to another, but this isn’t the case. The information that entanglement is able to communicate is random and as such is impossible to control.

BEAMING THINGS UP

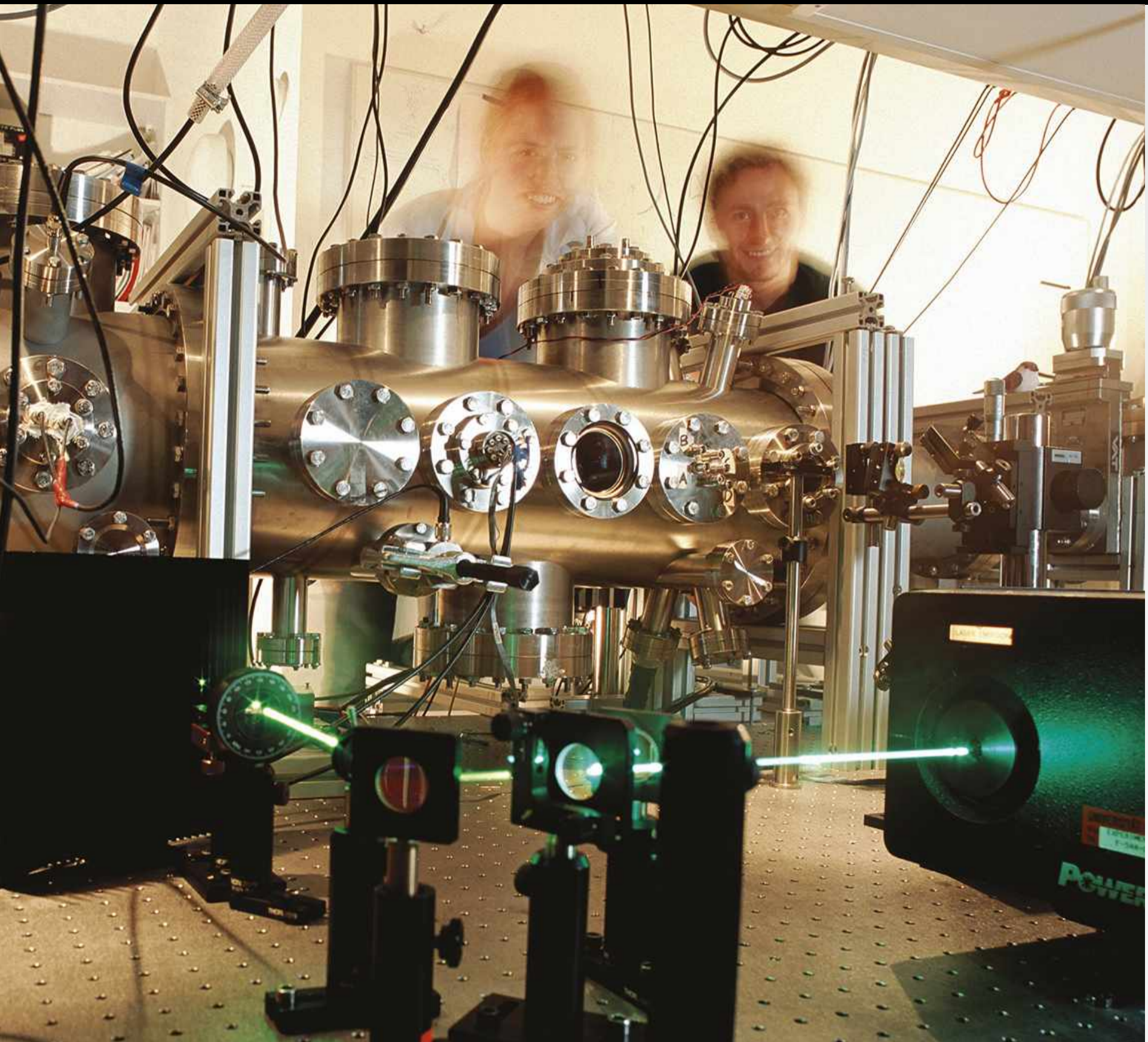
In order to successfully teleport an object, the teleportation device has to make an exact copy, down to the quantum state, of each particle. If it doesn’t, the transported



Albert Einstein (right) and Niels Bohr (left) came up with a theory of quantum teleportation after a long-standing argument



A change in one entangled particle affects the other instantly



Equipment used in a quantum entanglement experiment at Vienna University, Austria, which split entangled photon pairs

version would be subtly different. For instance, the beamed down Mr Spock might find himself thinking Dr McCoy's thoughts – or worse, might disintegrate into a pile of dust. However, even if we could make an exact copy of an object, it is impossible to discover the exact state of a quantum particle without altering it when doing so. This means that it's impossible to make a perfect copy of a quantum particle to produce identical twins – something that was proved mathematically in the 1980s by William Wootters and Wojciech Zurek.

There was, however, a loophole. It is possible to transfer properties from one particle to another, provided the values are never revealed as this would mean the original particle ends up being scrambled. Entanglement



This tunnel under the River Danube was used to teleport information about a photon down one of the wires on the left

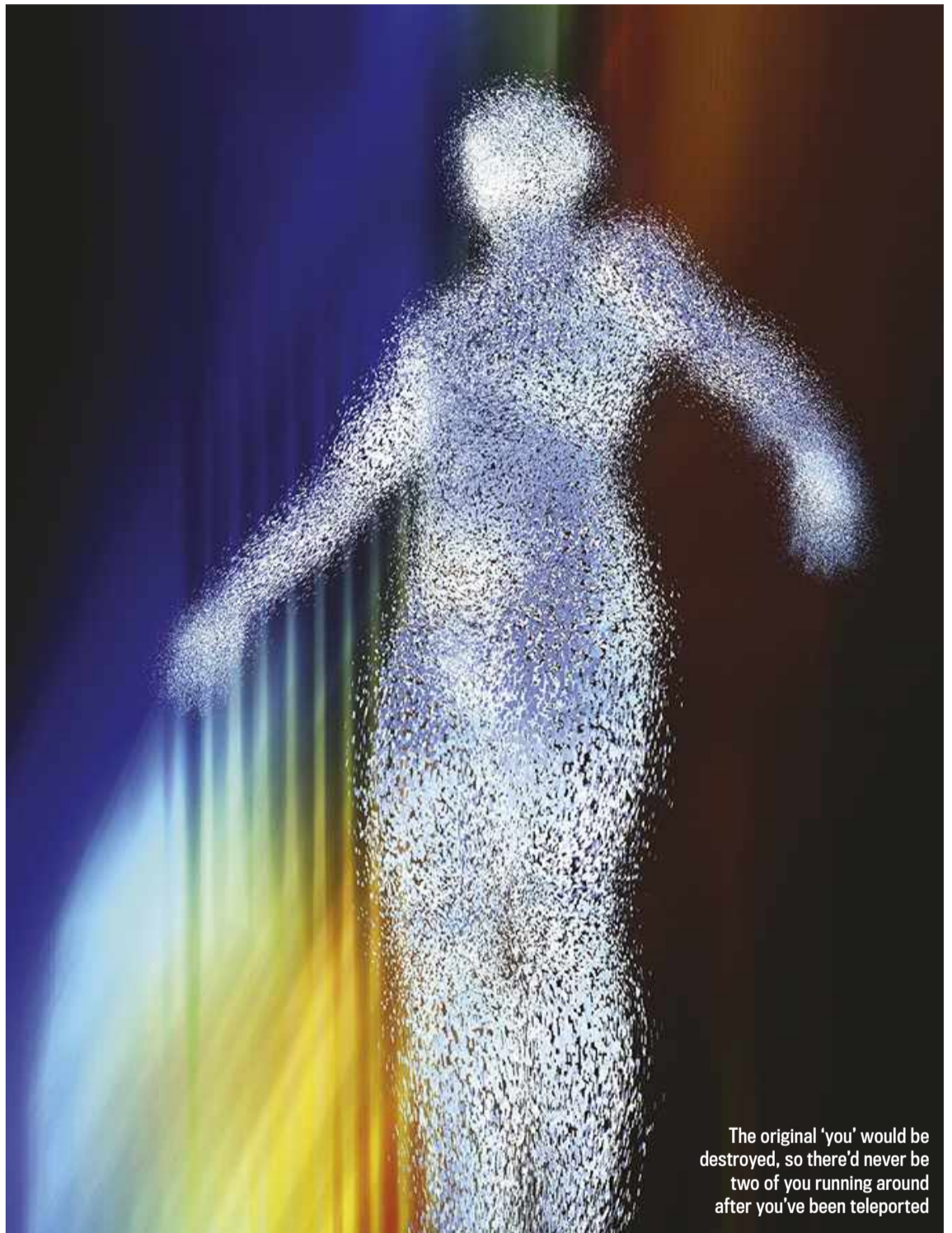
WILL IT EVER BE POSSIBLE TO TELEPORT A HUMAN?

The energy needed to teleport someone makes it impractical, but even if you could beam-up, would you want to?

AS AIR TRAVEL gets ever more tedious, the idea of simply popping into a booth on one side of the world and reappearing on the other gets ever more appealing. Standing in the way of this, however, are a tremendous number of technical issues. It may be possible to teleport a very small item, such as a virus, but for anything larger there are physical limits that mean it would be necessary to do the transfer particle by particle.

Even leaving aside our inability to manipulate matter accurately at that level, the sheer size of the problem is phenomenal. A human body contains around 7×10^{27} atoms (where 10^{27} is 1 with 27 zeros following it). Imagine you could process a trillion atoms a second. It would still take 7×10^{15} seconds to scan a whole person. That's 200 million years! There's also a huge amount of data to be transmitted with an associated energy cost. A conservative estimate puts this at around 10^{12} gigawatt hours. The UK's power station capacity last year was 83 gigawatts. So teleporting one human would tie up the UK power supply for more than a million years.

Even if it were feasible, sensible travellers would hesitate to make use of a teleportation device. Bear in mind that it would not move you from A to B. Instead it would strip you down, atom by atom, disintegrating your body, and building an identical copy. Yes, the teleported 'you' would seem the same to everyone else – with the same thoughts and memories. But it would be a copy and you would be destroyed. Even airport security isn't that bad.



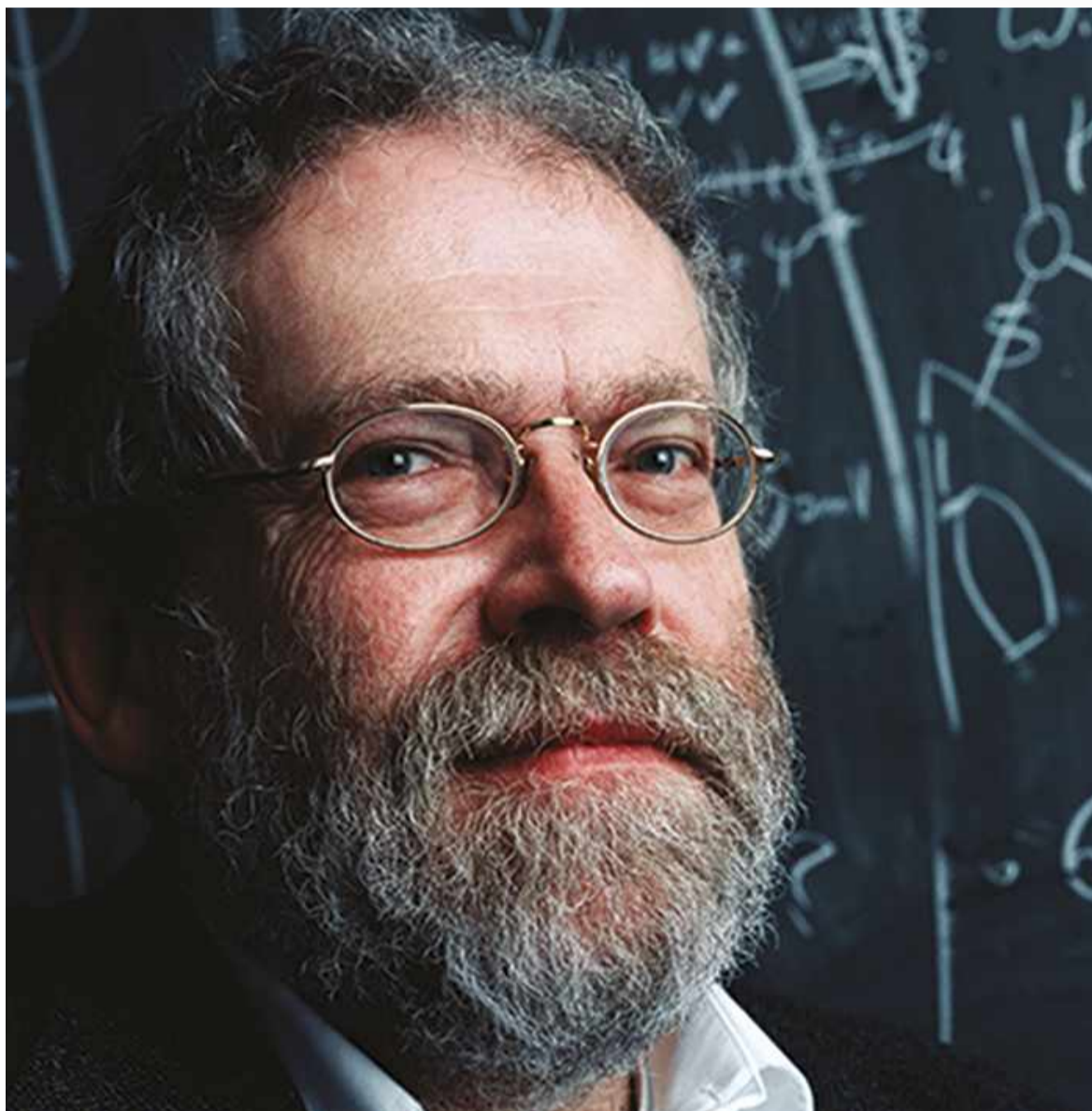
The original 'you' would be destroyed, so there'd never be two of you running around after you've been teleported

→ provides the mechanism to make that happen. This idea cropped up at a symposium in Montreal in 1993. Charles Bennett, a researcher at IBM, suggested that a pair of entangled particles could provide the essential hidden communication channel. As Gilles Brassard, the event's organiser remarked: "After two hours of brainstorming, the answer turned out to be teleportation. It came out completely unexpectedly."

The process of quantum teleportation requires the use of three particles. We start with an entangled pair of particles,

"Teleporting photons is the first step in supporting a quantum computer that uses the states of quantum particles as 'qubits'"

keeping one at the transmitter and sending one to the receiver. A third particle is the one to be teleported. This is made to interact with the first entangled particle, resulting in instant, unseen changes in the entangled partner at the receiving end. The transmitter then makes measurements of its two particles. This process reveals information, such as the particle's spin or polarisation, that is sent by conventional communication to the remote particle. The result: the distant, entangled particle takes on the state of the source. A particle has effectively been transmitted from A to B.



Quantum entanglement scientist Anton Zeilinger successfully teleported photons across the River Danube



Zeilinger uses quantum cryptography to make a bank transfer

It was only four years later that Anton Zeilinger in Vienna and Francesco de Martini in Rome demonstrated partial teleportation, transferring the polarisation of one photon to another. By 2004 Zeilinger had teleported the polarisation of the source photon across the river Danube, sending entangled photons down a fibre optic cable through the sewers and transmitting the conventional information by microwaves for 600m across the river.

It might seem that teleporting photons is irrelevant – after all, it is not difficult to get light from one place to another at high speed. But the principle could be applied to the quantum particles of matter as well, and teleporting photons is the first step in supporting a quantum computer that uses the states of quantum particles as ‘qubits’ – the quantum equivalent of bits in a conventional computer. “Quantum teleportation is the only method we know by which we can transfer quantum information reliably over large distances,” says Dr Ronald Hanson of the Delft University of Technology.

In the 10 years since that Danube experiment, most effort has gone into making quantum teleportation robust and repeatable, and extending the process from photons to atoms. Without quantum teleportation there can be no quantum computing, which offers the possibilities of undertaking calculations, like complex data searches, that would take a

conventional computer the lifetime of the Universe to complete.

In 2009, a team from the Joint Quantum Institute (JQI) at the University of Maryland and the University of Michigan transferred a quantum state from one atom to another one metre away, teleporting successfully 90 per cent of the time. The Maryland work was built on at the University of Delft this year, teleporting a property called ‘spin’ between electrons across three metres with a 100 per cent success rate. These electrons were trapped in diamonds. A pure diamond is a perfect lattice (3D structure) of carbon atoms, but by combining nitrogen impurities with gaps in the lattice, an electron can be trapped in a gap to act as a qubit.

This was another important stepping stone to making teleportation the communications channel for a functional quantum computer. Dr Hanson commented: “Our experiment is the first to show teleportation between two solid-state chips. Since we believe that a future quantum internet will consist of nodes made out of small quantum computer chips, this feat is very important.”

At the same time, others extended the range with the current record of 143km (88 miles) being held by Zeilinger. A Chinese satellite to be launched in 2016 will carry quantum communication experiments to look at the possibilities for handling entanglement and teleportation between space and Earth, an essential first step to creating a quantum internet.

These experiments appear to put the three-metre Delft transmission firmly in the shade, but the long-range tests have success rates of only around 1 in 1,000. This makes the approach impractical for real-world computing tasks that rely on accuracy and gives Delft’s approach the edge, explains Dr Hanson. “We know when we have created entanglement without destroying it. This way we can use that entanglement in a subsequent experiment for teleportation that works every time.”

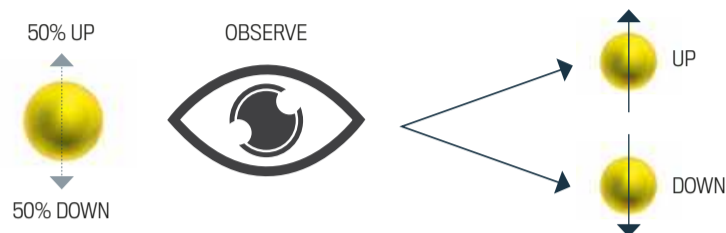
SLOWLY BUT SURELY

There is a long way to go. As Chris Monroe of the JQI/Michigan team points out, both the JQI and Delft experiments had a flaw. “[They were] painfully slow: one successful qubit event every five minutes or so,” he explains. “The probability of successfully



A STEP-BY-STEP GUIDE TO QUANTUM TELEPORTATION

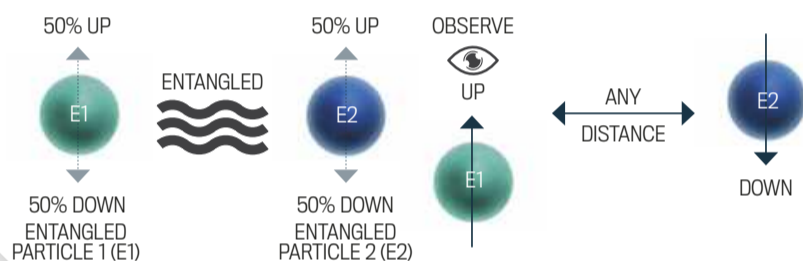
1 Superposition: Quantum particles have various properties, including 'spin'. For electrons, this comes in two forms – up and down – but until it's actually measured, the spin of the electron is a mix of both possibilities. This is known as a "superposition" of states.



3 No instant messaging: Entangled particles respond to measurements on their partners immediately, regardless of distance. Faster-than-light communication isn't possible, as any interaction with the "sender" particle randomly puts it into up or down states, so you can't send non-random signals to its "receiver" partner.



2 Entanglement: It's possible to create or manipulate particles so that their properties become intimately connected or "entangled". This allows measurements on one particle to reveal properties of its entangled partner without actually observing it. So if one entangled electron is observed to have spin "up", its partner will have spin "down".

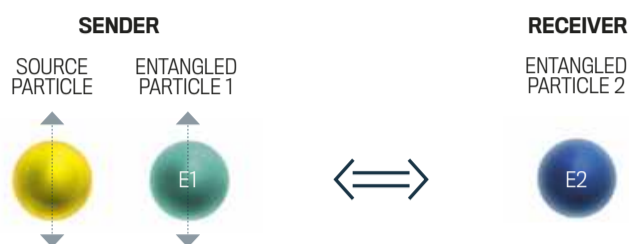


4 Good for keeping secrets: The best way to keep data secure is to mix it with a random "key". The problem is that any recipient needs to be sent the same key to unscramble the garbled message – raising the risk of interception. Sending the key as entangled photons of light helps combat this, as interception damages their entanglement.



US Army researchers Patricia Lee and Ronald Meyers pose with equipment designed to manipulate photons to help develop future quantum technologies

5 Teleportation begins: Entanglement also allows particles to be teleported from one place to another. The “source” particle to be transported is allowed to interact with one of a pair of entangled particles, whose partner (the “receiver”) is then dispatched to the destination.

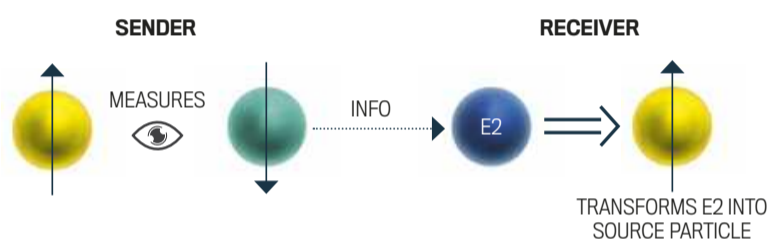


7 Qubits: Conventional computers process simple binary 0 and 1 states or “bits”. In contrast, a quantum computer uses so-called qubits, in the form of superpositions of particle states such as up and down. By being able to represent two states simultaneously, just 100 such qubits can do the work of $2^{100} = 10^{30}$ conventional bits.

QUBIT



6 Teleportation ends: The “source” then has all its properties beamed to the receiver by two routes: some directly and some via the receiver’s entangled partner. This circumvents the ‘uncertainty principle’, which forbids perfect knowledge of all a particle’s properties simultaneously. The receiver particle is transformed into the source.



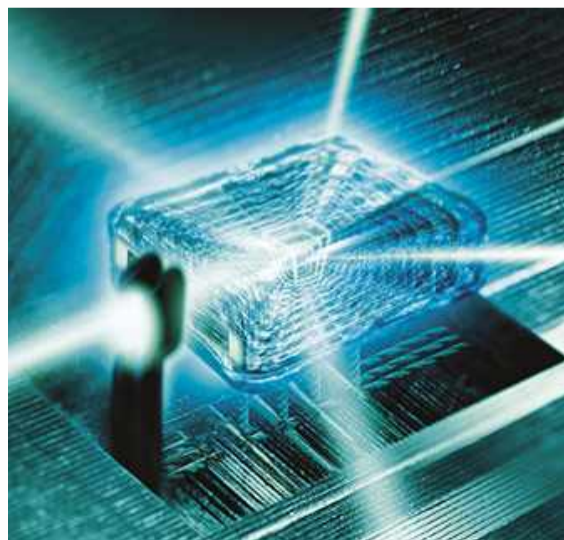
8 Teleporting qubits: A major challenge in using qubits is simply transporting them, as their superposition is easily disturbed, destroying their number-crunching power. Teleportation is the answer, with qubits made from photons having been successfully teleported over 140km in 2012.

SENDER

RECEIVER



“When Captain Kirk is teleported from the planet to the Enterprise, not a single atom in his body makes the trip”



Light hits the crystal core of a quantum computer; developments in teleportation could soon make such a device a reality

generating entanglement in both experiments was very small, about one in 10 million... This means that there is no way to scale them up for teleporting larger systems.” However, Monroe’s team has since managed to speed up teleportation by a factor of 5,000, bringing the process somewhat closer to a practical solution.

SECRET SERVICE

The US Army is now developing a quantum communication system for transmitting secret messages. The prototype method involves creating photons to carry the information, and then allowing these to interact with entangled pairs of photons, half of which are dispatched to the recipient. Any attempt to intercept the photons en route will be revealed by corruption to the delicate entanglement. The challenge facing the US Army scientists lies in minimising the level of damage done to the photons as they travel through the chaos of a battlefield.

Teleportation for quantum computers seems feasible soon. But could we ever teleport a tangible physical object? A human seems unlikely (see ‘Will it ever

be possible to teleport a human?’, p44’), and Chris Monroe points out that even a single large molecule would present a significant challenge. “If you are interested in teleporting the state of a DNA molecule, there are so many degrees of freedom, so many possible configurations, that it will be very difficult to imagine doing this anytime soon,” he says.

As for a person, could you physically send the ingredients, but teleport the instructions for building them? “When Captain Kirk is teleported from the planet to the Enterprise, not a single atom in his body makes the trip,” says Monroe. “In the receiving pod, all the atoms that make him should already be there, and the only thing being transported is the exact configuration and quantum information encoded between all of his atoms. I don’t know what Captain Kirk’s ‘substrate’ would look like, but I don’t suspect it would be pretty.”

We might not beam up any time soon, but at least quantum teleportation brings us a big step closer to usable quantum computers. ■

BRIAN CLEGG is the author of *Life In A Random Universe*. His latest book is *The Quantum Age*

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DON'T TRY THIS AT HOME!

You may have seen a live science demonstration before, but the work of this Spanish physicist is something else. Prepare to be amazed as his tricks of the trade are revealed by **Hayley Birch**

PHOTOGRAPHY BY ALBERT CHUST/CREACIENCIA.ES

Dani wears a soapy glove that enables him to hold a bubble without bursting it. The bubble is coloured with a pigment that fluoresces under UV light, emitted by his futuristic suit

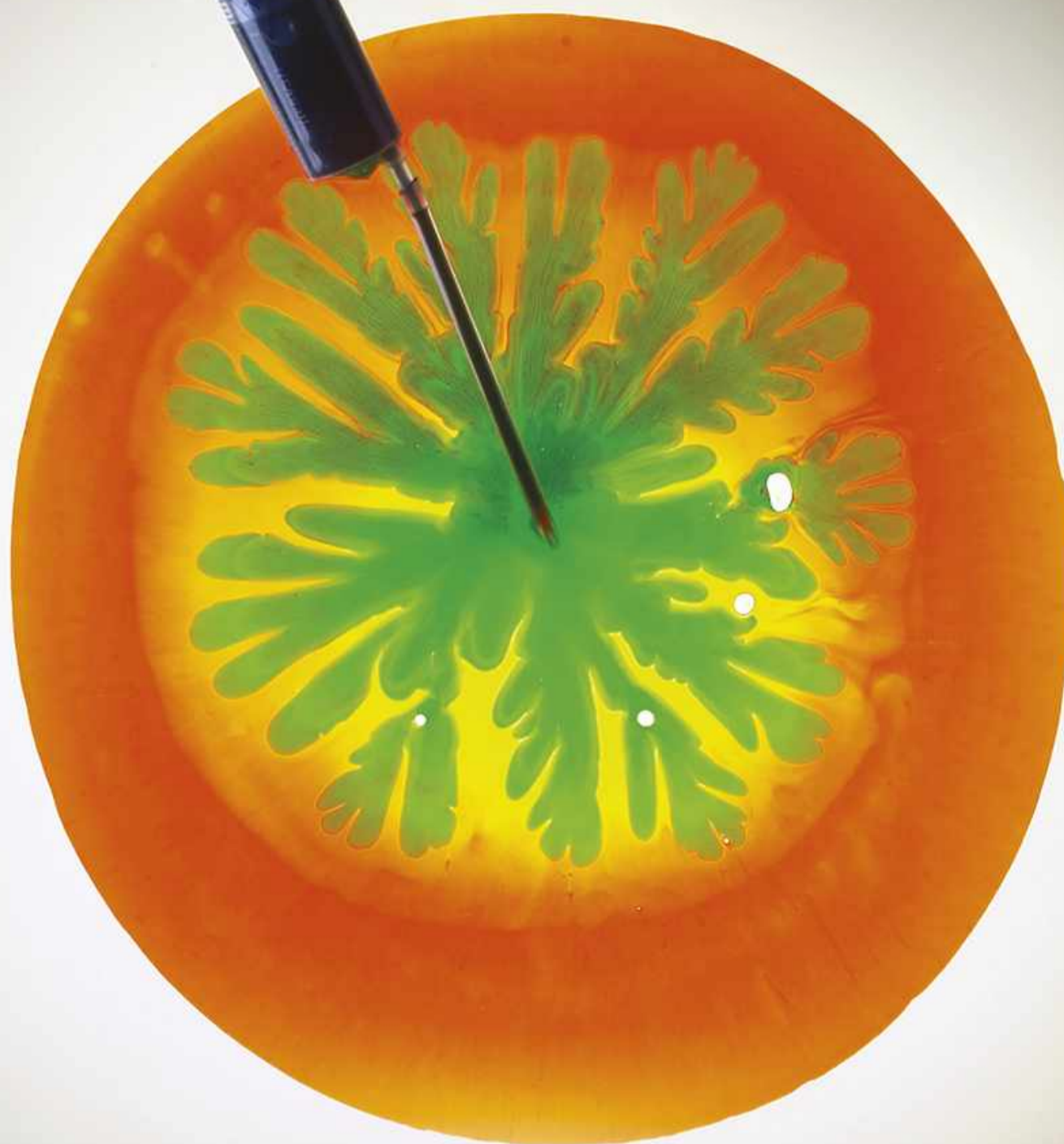
THERE'S AN ART to scientific demonstration and it's certainly in evidence in these images. Barcelona-based physicist Dani Jiménez has been surprising live and television audiences with his visually stunning experiments for over a decade. From freezing bubbles to lighting a fire that burns underwater, many prompt the question 'How did he do that?', as if there were some trick or illusion. But the photos prove there's no sleight of hand. And while a magician never reveals his secrets, a physicist... well, as Focus found out, a physicist can be persuaded. ➔

FROZEN BUBBLES

ALMOST ANYTHING WILL freeze if you make it cold enough – even bubbles. You just have to get them to freeze before they burst. Here, Jiménez blows his bubbles directly onto liquid nitrogen. “This substance is really, really cold – about -200°C ,” he says. “So when the bubbles come into contact with liquid nitrogen, they start to freeze.” The frozen bubbles are very fragile and break easily if you try to pick them up. They also melt if they get too far away from the cold nitrogen. But as the two half-bubbles in this image show, they’re still much more stable than regular liquid bubbles. Jiménez adds glycerine to his mixture to help stabilise the bubbles, but ordinary soap and water would work too, he says.

“The frozen bubbles are very fragile and break easily if you try to pick them up”





Witness the beauty of nature's fractal patterns with water, glycerine and two sheets of glass

NATURAL FRACTALS

SHAPED LIKE A sprig of parsley, the green pattern at the centre of this image is made by squirting water into a thin layer of glycerine sandwiched between two sheets of glass. The liquids are mixed with food dyes to help make things easier to see. But although the pattern is pretty, it's not immediately obvious

what's so fascinating about it. It is, however, a fractal. This means it's repeated at different scales, so if you zoomed in, you would see a similar pattern at a closer magnification. The repeating shapes of fractals are found all over the place in nature, from snowflakes to Romanesco broccoli to pineapples. Jiménez uses a syringe attached to a fine tube to squirt the green-dyed water into the glycerine through a tiny hole in the glass plate.

"We just pull the syringe and the water gets into the glycerine and creates the fractal," he says. "It's really important that there's no

air inside." The set-up relies on there being an extremely small gap between the two plates. It's known as a Hele-Shaw cell, invented by the English engineer Henry Selby Hele-Shaw – also, incidentally, the inventor of an early car clutch – for studying the flow of fluids to solve problems in mechanics. In the 1980s, physicists used Hele-Shaw cells to push water through a more viscous fluid, like glycerine. They found that it formed branched, fractal patterns that they called 'viscous fingers', something that was used to understand the behaviour of oil around oil wells.

It's not what you'd typically see on a clothes line, but with a bit of trickery you can reveal the plastic structure of a can; hydrochloric acid reacts with the can's aluminium, leaving plastic behind

“Dip an aluminium can in hydrochloric acid and the acid attacks the aluminium, leaving only the plastic coating”



UNDRESSING A CAN

ACID EATS METAL – that's the essence of this can-stripping demonstration. Dip an aluminium can in hydrochloric acid and the acid attacks the aluminium, leaving behind only the plastic coating of the can. In the image above, the shapes of the cans – though a little crushed – are still recognisable, but according to Jiménez, it's not that easy to get good results. “This experiment is difficult because the plastic is really soft and breakable, so you have to be careful when you handle it,” he says. “Some of the cans broke when we took the photos.”



For perfect results, sand off the printing on the can first to let the acid get to the aluminium



A selection of tools (left) are needed for this task as you don't want your hands anywhere near the hydrochloric acid (right) that does the job of dissolving the aluminium



A MASK OF DUST

JUST LOOKING AT this image, you could be forgiven for thinking the beaker is full of some nasty, mummifying solution, or that the demonstrator has covered his face in clay. In fact, the substance coating Jiménez's face is an extremely water-repellent type of dust or

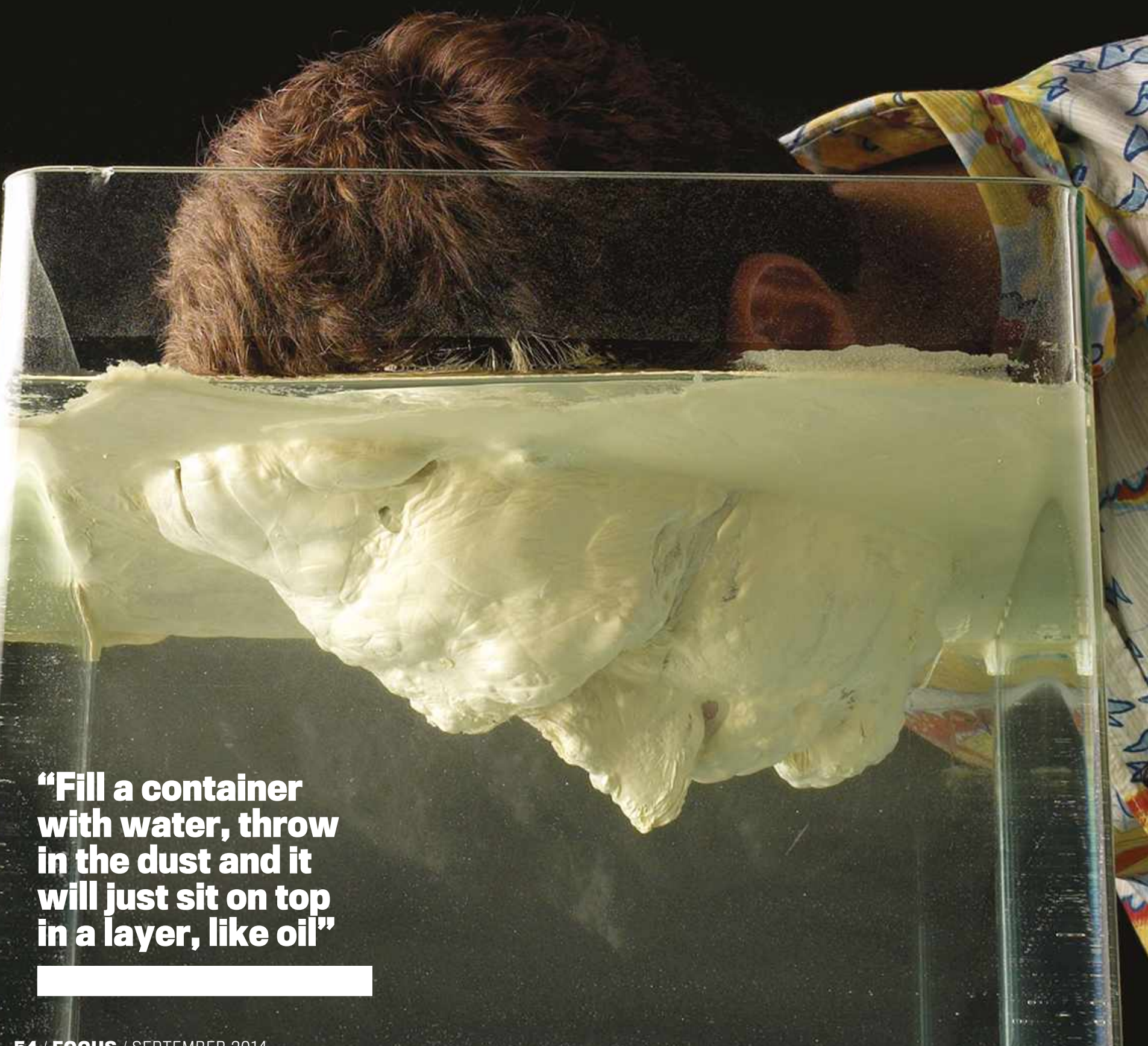
powder made from the natural spores of a moss called *Lycopodium*, otherwise known as creeping cedar.

You can fill a container with water, throw in the dust and it will just sit on top in a layer, like oil. This is thanks to its hydrophobic (water-repelling) quality. *Lycopodium* spores do in fact contain large quantities of oil. Any object that is placed in the container is then protected from getting wet by the dust, which clings to skin.

"You can put your hand or face inside the container and the *Lycopodium* will create

a glove or a mask around you. So, when you take the hand or face out it is absolutely dry," says Jiménez.

Once upon a time, the moss powder was used as fingerprint dust. It has also been used in latex gloves and condoms to stop the latex sticking together, although the spores are known to cause allergic reactions. Nowadays, it is used by the film industry to create flashy special effects; because it has such a high fat content, the powder goes up in flames very easily.



"Fill a container with water, throw in the dust and it will just sit on top in a layer, like oil"



BIG SPLASH, LITTLE SPLASH

EACH OF THESE glasses contains the same amount of three different liquids – clockwise from top: water, oil and glucose. But when the same object – here, a big bolt – is dropped into each glass, it creates a splash that looks remarkably different when captured on camera. This is all down to the viscosity of the different fluids, or how ‘thick’ they are.

The water is not very viscous, but the oil is a bit more so and the glucose is so thick that it barely leaves the glass when the screw is dropped in it. The same experiment gives slightly different results if you heat the liquids. “Oil and glucose would be a little less viscous if you warmed them up,” Jiménez explains. So you’d see a slightly bigger splash. Water, on the other hand, is fairly resistant to rising temperatures, so its splatter would be barely altered. This resistance to change is unusual among chemicals in nature and important. It means that organisms that live in, or depend on it, are to some extent protected from changing conditions.





Find out more

To watch Dani Jiménez in action, check out some of his experiments on YouTube at www.youtube.com/user/CreaCiencia

UNDERWATER FIRE

THIS DEMONSTRATION MAY look impressive, but somewhat counter-intuitively there's nothing particularly difficult about getting fire to burn underwater. It just needs a little help. If you can get your hands on some standard sparklers, you can try it out.

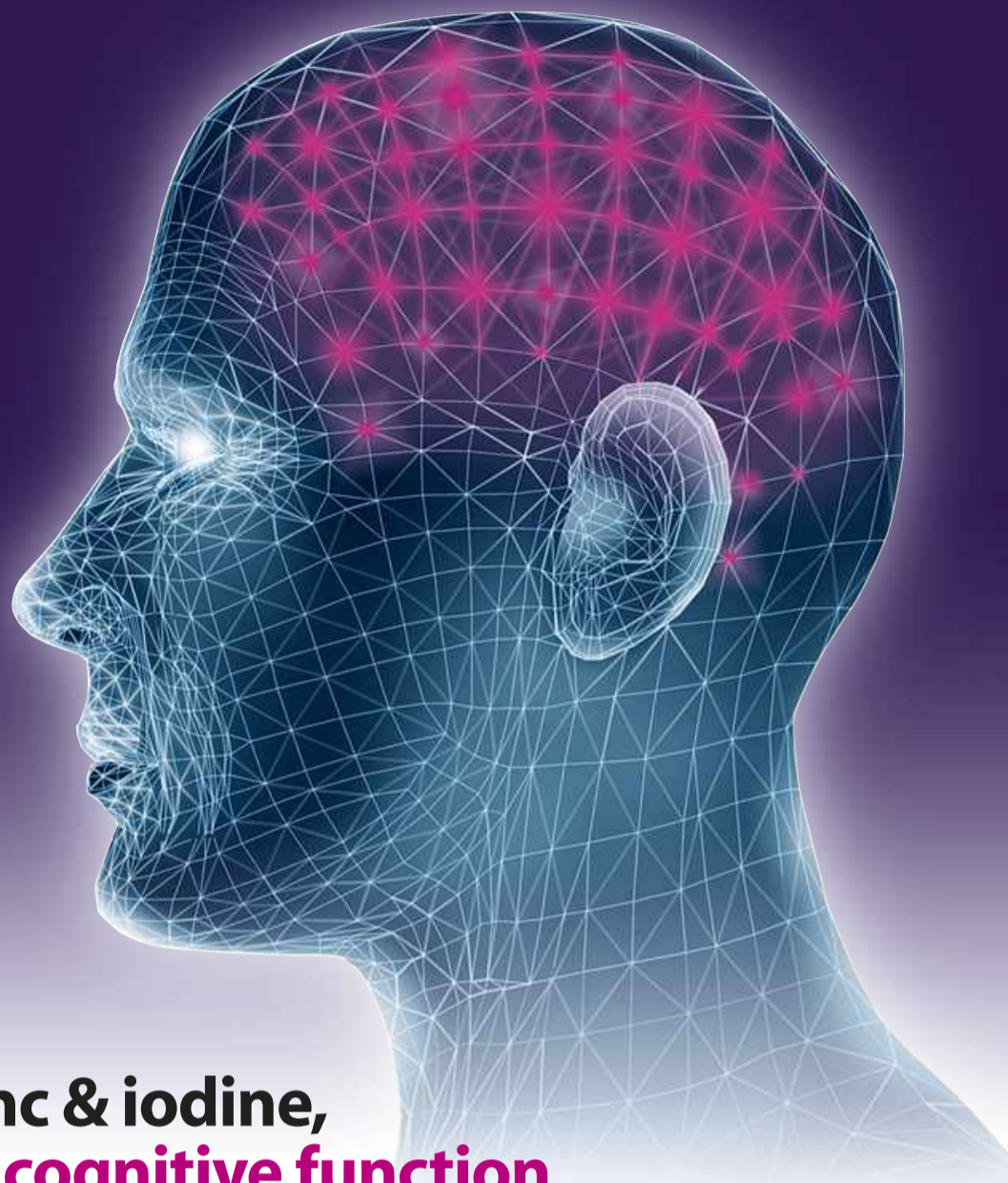
Fire needs oxygen to burn, which it usually gets from the oxygen (O_2) molecules in the air. There's oxygen in water too, but it isn't

available because it's locked up in the water (H_2O) molecules. However, sparklers contain oxidisers – chemicals like potassium nitrate (KNO_3) that provide extra oxygen. Just taping some sparklers together, lighting them and dunking them in a glass of water creates underwater fire, although, says Jiménez, it burns a little less brightly than in the air. However, the tricky bit is photographing it.

"We used a long exposure," he explains. "It's really important here to be in absolute darkness, so the sparkler's light is the only light when you capture the image. In these conditions you can capture the complete movement."

HAYLEY BIRCH is a science writer and author of *The Big Questions In Science*

Feed your mind



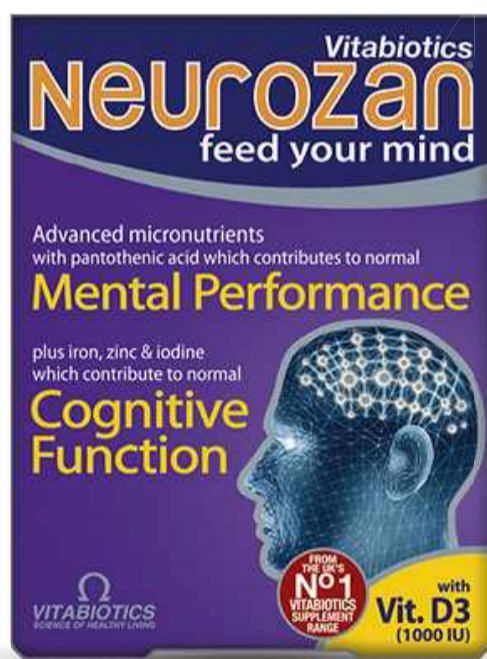
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A NEW F





FORMULA

FIRST RACE

13TH
SEPTEMBER

September sees the start of a whole new motor racing championship. It'll be slower and quieter than F1 but, as **Rob Banino** discovers, it could be far more important

JULY BEGAN LIKE most months at the Donington racetrack, with high-performance cars being put through their paces on the Leicestershire circuit. But there was one difference: instead of echoing to the familiar cacophony of high powered combustion engines, the air around the circuit was quiet and calm.

The peace was only interrupted when one of the sleek, new racers being tested came rushing by, whooshing like some kind of futuristic fighter jet. The cars were making a new and unusual noise; a noise that

caught your attention but sounded nothing like the typical roar of a racing car. And that's because the cars were not typical racing cars. They were Formula E racers.

ELECTRIC MOTORS

Formula E is a new racing championship for single-seater cars that are powered solely by electricity. It's a novel twist, but with so many existing classes of motor racing – from Formula 1 and Touring Cars to GT Endurance and NASCAR – do we really need another?

Alejandro Agag, the CEO of Formula E



ILLUSTRATOR: ACUTE GRAPHICS



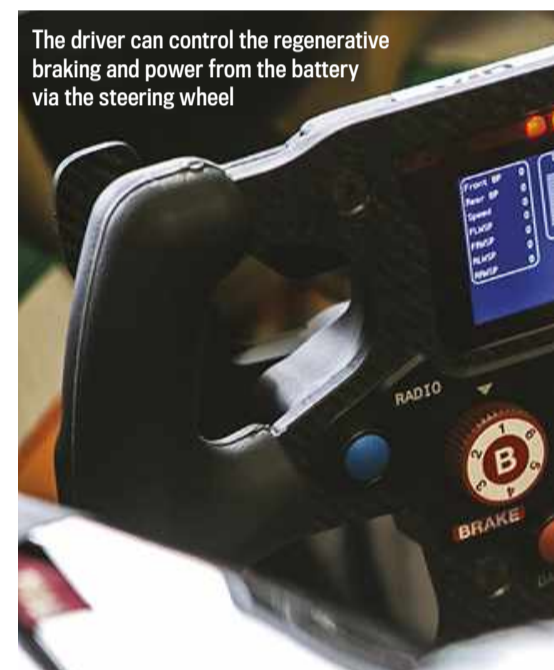
Formula E is launched at a special event in London, with the cars showing the public what they're capable of



Michelin puts a set of tyres for the competition through their paces in wet conditions



The driver can control the regenerative braking and power from the battery via the steering wheel



➔ Holdings, would argue yes. The Spanish businessman says there are two reasons why we need Formula E. “The first is to make electric cars more popular – to show them racing and use the sport to get people interested in them. The second is to use the races as a platform for research and development to improve electric powertrains, batteries and charging systems.”

And we need to develop this technology because the pollution caused by combustion engines in congested cities, and dwindling oil reserves, mean there's a need for cleaner, more energy-efficient and sustainable transport options. Agag believes electric

vehicles are one way to meet that need.

But electric cars are not without problems; problems that may put some people off – the biggest one being their range. And it's a problem that will need to be solved quickly because, right now, a Formula E car's battery doesn't have enough energy to get it through a race.

BATTERY POWER

For the first year of the Formula E championship, all the cars are running stock equipment, so they all have the same battery built by Williams, the company behind the Formula 1 team. It's a lithium-ion unit based on the

one Williams made for the Jaguar C-X75 hybrid supercar.

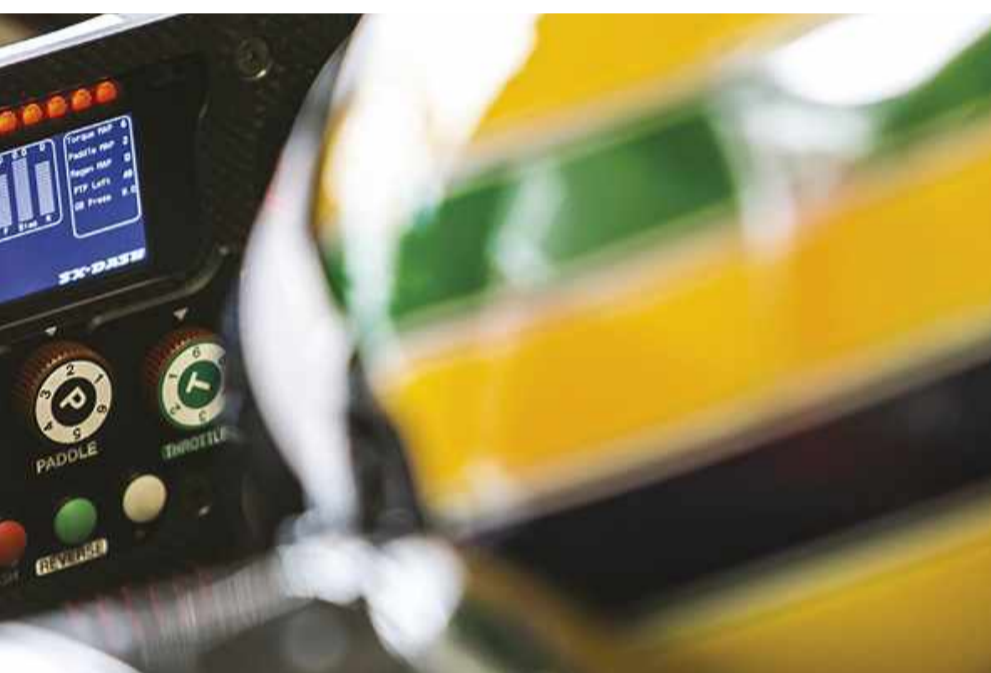
It's similar to the battery you'd find in a laptop or mobile phone, but has a lot more cells and a slightly different chemistry. “Within lithium-ion batteries there are different chemistries and each of them is better suited to different applications, so you have to select the right one,” explains Okan Tur, chief technical specialist for hybrid systems at Williams.

“There are better chemistries for power, better chemistries for energy and there are better chemistries for applications that lie in between those two. We've selected one of those but, to keep our competitive edge, we're not declaring

which chemistry we're using at the moment,” says Tur.

But while the Jaguar C-X75 can use its petrol engine to reduce the drain on the battery and increase the car's range, the Formula E cars don't have that luxury. So, for the first season, to make it to the chequered flag, the drivers will have to come into the pits during the race and jump into a second, fully charged car.

Pit strategy will therefore shape the racing, but the winner will be the driver that can best manage the battery life during each car's stint on the track. And the cars have been designed to extend the life of the batteries as long as possible. “We don't have enough energy in the batteries



“The drivers will have to come into the pits and jump into a second, fully charged car”

for a long race with the Formula E car,” says Christophe Chapelain, Technology Manager for Renault Motorsport, who oversaw the construction of the cars. “So we must optimise the use of the energy and to do that we had to decrease the car’s [aerodynamic] drag as much as possible. This is why the car is the shape it is. We have structures in front of the

wheels to reduce drag and have done everything we can to make the car more efficient.”

TYRED AND TESTED

And that includes taking a whole new approach to the tyres. “This is the first time that a single-seater championship will use 18-inch [45.7cm] tyres,” says Serge Grisin, Technical Director for

endurance racing tyres at Michelin, the tyre supplier for the Formula E Championship.

“The wider diameter and smaller sidewall reduces the tyre’s rolling resistance. We chose 18-inch tyres because it’s very close to the size you find on a lot of road cars. That means the link and the technology transfer between Formula E and road cars is obvious. Other championships [such as F1] use 13-inch [33.0cm] tyres with big sidewalls, which isn’t relevant to road cars,” says Grisin.

The tyres also can’t be changed. Unlike in F1, where each car has 13 sets of tyres to choose from per race, each Formula E car is only allowed one set for each round of the

championship. So the rubber a Formula E car rides on has to last through practice, qualifying and the race, meaning the tyres have to be durable and efficient, but they also have to be able to perform in both wet and dry conditions. It’s a combination that caused a lot of head scratching at Michelin when it came to choosing the rubber compound, tyre construction and tread pattern.

The result is the Pilot Sport EV, a tyre that draws on the experience Michelin has gained in endurance racing. But it also shares some traits with the Energy EV, a road tyre developed specifically for the Renault ZOE that increased the small

Alejandro Agag CEO, Formula E Holdings



Where does the electricity used to charge the cars come from?

We’d like to get it from renewable sources. Where that’s not possible, Formula E has its own electricity generator that we can bring to races. It’s a very sophisticated, low-emission generator that uses glycerin from algae. It produces electricity with about 20 times less CO₂ than a normal generator.

Why are the races being held on city centre circuits?

Firstly, to show that while electric car technology is still evolving it’s definitely ready for the city now. Most people do very short commutes in the city – less than 10-15km a day – and for those journeys an electric car is ideal. Secondly, by staging races in cities we avoid tens of thousands of people having to drive to racetracks far away.

The Formula E cars are certainly green, but what about the other vehicles the teams use to travel between races?

That’s very important because transporting everything will emit CO₂. Our aim is to minimise CO₂ emissions of the logistics and we do that by using train and ship transportation over air transportation. We also source equipment locally as much as we can. There definitely is a carbon footprint, though, and we offset that with carbon credits.

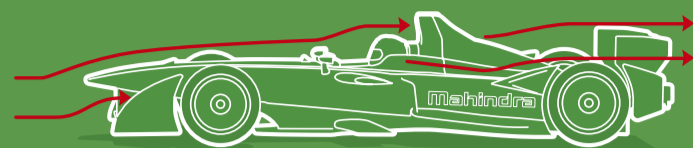
Can you explain how the ‘fan boost’ system works?

Formula E fans can vote online (at www.fiaformulae.com) for their favourite driver. The vote closes 10 minutes before each race and the three drivers with the most votes get a five-second boost of extra power in each of their cars. It’s equal to about 50hp and they can use it to pass someone or stop someone passing them. It won’t be a massive advantage, but it’ll be enough that if you’re running second it may help you take first place. But if you’re last it won’t make you win the race.



INSIDE FORMULA E

The technology that will drive motorsport into an electric future



Motor

Modelled on the motor found in the McLaren P1 supercar, it produces a maximum of 270bhp for use in qualifying. During races, it's limited to 180bhp, although the drivers who win the fan boost vote (see p61) will have an extra 50hp to deploy twice.

Safety lights

Since the motor is almost silent, LEDs in the roll hoop indicate whether or not it's running so mechanics and marshals can tell if it's safe to approach a stationary car.

Aerodynamics

The body has been engineered to optimise aerodynamic efficiency and reduce the drain on the battery. Formula E cars generate less downforce than Formula 1 cars and have more ground clearance to cope with the streets on the city circuits.

Steering wheel

Dials on the steering wheel control the settings for the regenerative braking system and the power from the motor. In the event of a crash, lights on the steering wheel indicate whether the impact had the potential to cause the driver a head injury.

Battery

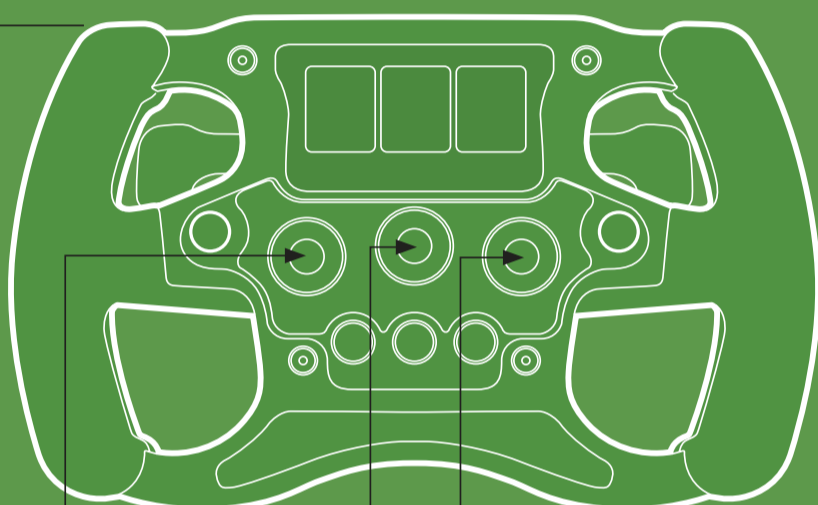
Built by Williams and based on the battery used on the Jaguar C-X75 hybrid supercar, the battery weighs 200kg, can provide up to 200kW of power and takes between 45 minutes and one hour to recharge. Air cooling is not sufficient to keep its temperature down, so a liquid cooling system uses a dielectric (non-conductive) fluid for safety.

Tyres

The cars use 18-inch treaded tyres made by Michelin for wet and dry conditions. No tyre changes are allowed and no tyre warmers either. Each tyre contains an RFID chip to collect data on its performance and ensure the tyres aren't swapped.



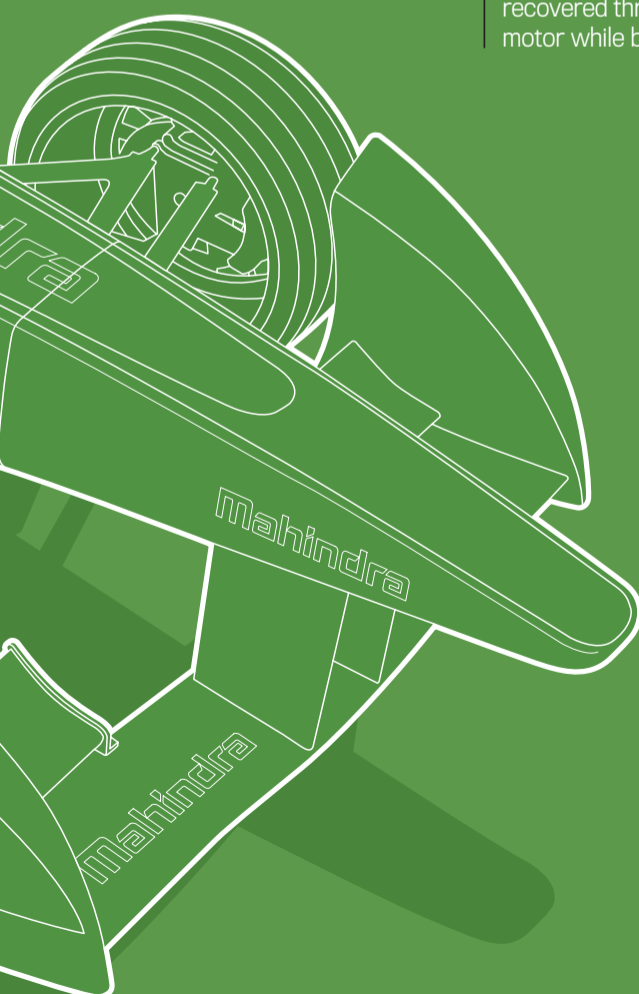
DIMENSIONS	500 (L) X 180 (W) X 125CM (H)
TOP SPEED	225KM/H (ESTIMATED)
0-100MPH	3 SECONDS
RANGE	APPROX. 25 MINS OF RACING
WEIGHT	600KG (PLUS 200KG BATTERIES)
MOTOR	200KWH (EQUIVALENT TO 270BHP)



Brake adjust - controls the stopping force applied by the brakes

Throttle adjust- changes how much power is available under acceleration

Paddle - adjusts the amount of energy recovered through the motor while braking



→ electric car's range by six per cent.

The aerodynamics, the tyres and everything else about the car have been designed to prolong the life of the battery, but sooner or later it still needs to be recharged. For now that means plugging the cars into a recharger but that's set to change.

"Wireless recharging technology is being developed by Qualcomm, one of Formula E's partners," says Agag. "[Rather than having to be plugged in], the car parks on a pad that recharges it by induction. The beauty of a wireless system is that it gives us two charging options: static and dynamic. For static wireless charging the cars have to park on a charging pad... but with dynamic charging the cars could

Mannen of McLaren, the makers of the Formula E motor, explains, part of the reason for that is the way electric motors perform. "The thing about an electric motor is that it provides torque instantly - as soon as you turn it on you create torque and as soon as you turn it off you create braking," he says. "So electric motors are most interesting, and potentially the most fun, on courses that involve a lot of stopping and starting, which is a characteristic of city circuits."

So the cars being fine-tuned around the Donington racetrack in July are ultimately bound for street circuits in cities such as Beijing, Buenos Aires, Long Beach and London. The first race is in China on 13 September and will see the cars racing past the Bird's

"The first race is in China on 13 September - the cars will race past the Bird's Nest stadium"

recharge as they're racing."

Dynamic wireless charging technology already exists and is used to recharge robots as they move around factory floors performing tasks. "The [same] technology could work in cities," suggests Agag. "You could place the static charging pads in car parks, but even if you put them at traffic lights, your car would get a small amount of charge when you stopped at a red light. And if you were to incorporate the dynamic charging technology into the roads you could keep your car going forever."

STREET RACING

The technology Formula E is being used to develop will take a few years to reach the streets, but the cars will be there from the start, because the championship will be contested on city centre circuits. And, as Peter van

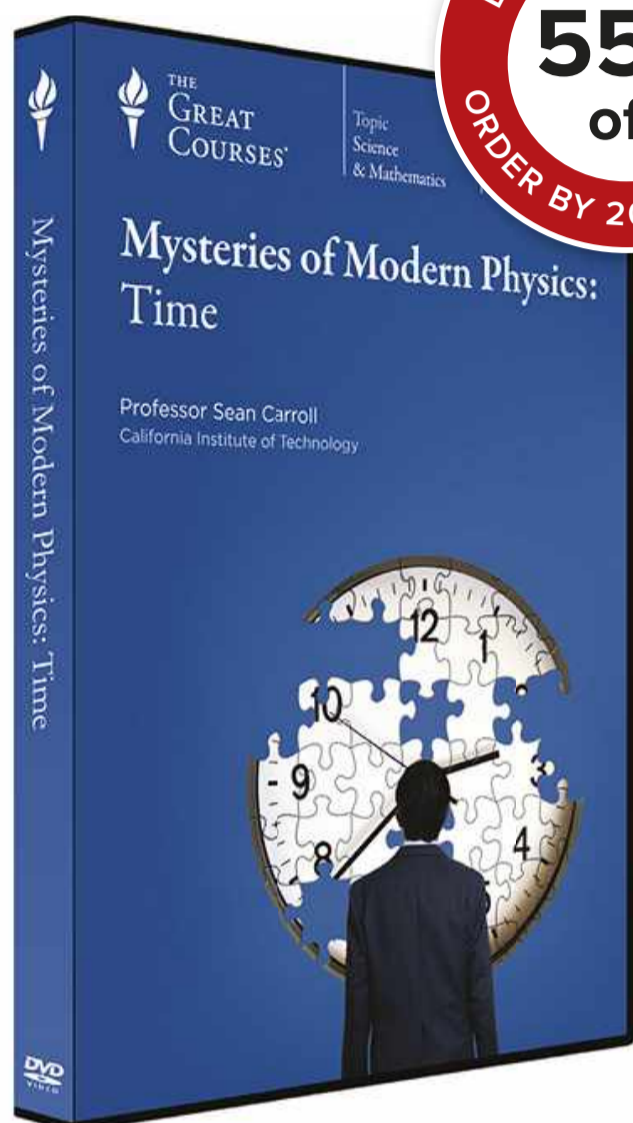
Nest stadium used for the 2008 Olympics. From there the championship will travel around the world to showcase the current state of electric car technology and improve it.

The teams and drivers will look to make improvements to win races, but the aim of the championship is for those improvements to lead to energy-efficient road cars. At its heart, Formula E is a laboratory for developing advanced vehicles and cleaner, more sustainable methods of keeping them going. If it manages to do that, it could be one of the most important laboratories in the world. ■

ROBERT BANINO is a science writer and editor

Find out more

Check out Formula E's official website at: fiaformulae.com



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ROBERT MATTHEWS

After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University



GARETH MITCHELL

Starting out as a broadcast engineer, Gareth now writes and presents *Click* on the BBC World Service



LUIS VILLAZON

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*

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Q ANN LEWIS, SOUTHAMPTON

How precise is robotic surgery?

A PICTURED IS THE Da Vinci robotic surgery system. It's an arrangement of four spider-like arms operated by a surgeon at a control panel in the operating theatre just a few metres from a patient. The surgeon uses it to control the tip of a scalpel, for instance, with sub-millimetre accuracy. Incisions can be smaller than in conventional surgery and there is less bleeding, reducing recovery times in prostate operations from six to two weeks.

The motion is scaled such that when a surgeon moves their hand, the instrument tip will only move a fraction of that distance, allowing more precise movements. According to makers Intuitive Surgical, the instrument tip can move just 1mm for every 3mm moved by the surgeon's hand. The doctor also uses a 3D vision system, along with a camera inside the patient, so the procedure can be viewed in minute detail. **GM**

A surgeon practises with the Da Vinci robot



PHOTO: CAMERAPRESS

In Numbers

7.4 metres

is the wingspan of the largest fossilised flying bird, found recently in North Carolina. The 6-million-year-old seabird, named *Pelagornis sandersi*, was twice the size of today's largest bird, the wandering albatross.

Q COLIN DALY, ISLES OF SCILLY

How do gravitons escape from a black hole?

A IN EINSTEIN'S THEORY of General Relativity, the force of gravity around a black hole is described solely by the warping or curvature of 'space-time'. However, many scientists believe we can also describe gravity, just like the other forces of nature, as the exchange of 'virtual' particles – in the same way that particles of light, photons, carry the electromagnetic force.

Unfortunately there is, as yet, no such quantum theory of gravity that would describe how it works at this level, although we have some clues as to what it might look like. But crucially, these 'virtual' gravitational particles (called 'gravitons') aren't bound by the normal rules of physics. They can pretty much do what they like, including travelling faster than light, as long as they do it before we notice them! Consequently, a black hole's event horizon presents no barrier to gravitons and hence their communication with the outside Universe. **AG**



Powerful jets of X-rays emanate from the realm of a supermassive black hole at the heart of galaxy Arp 220

Q CAMILLA BRYSON, LONDON

Are identity parades fair?



Do you recognise all these actors in *The Usual Suspects*?

A I WAS IN an identity parade, many years ago. I was asked by a policeman to take part in the line-up because I had the same build and hairstyle as the suspect. We were paid £5 for our trouble and as we queued in a side room an officer burst in and exclaimed: "There he is!" It turned out that the suspect had managed to slip away and join the group of innocent lookalikes without the desk sergeant noticing him!

It seems that the task of accurately remembering the faces of people we have only seen briefly is much harder than we think. The problems with identity parades

have been born out by recent research. One study at the University of Arkansas found that for every extra metre between you and the suspect when you originally saw them, your chance of correctly identifying them in a line-up drops by half a per cent. This is because it's only at close range that we pay attention to specific features that distinguish one face from another.

Another study at the Open University found that the older you are the more likely you are to make an incorrect identification and yet the more confident you will be that you are correct. **LV**

Q BERNADETA DADONAITE, LONDON

Do birds fly through clouds?

A MOST BIRDS FLY no more than 150m off the ground and so won't be inside cloud unless it's foggy. But migrating birds can climb to 6,000m and the highest ever observed was a flock of whooper swans (*Cygnus cygnus*) at 8,800m. That's high enough to put them above low- and medium-altitude clouds, including the stratus and altostratus clouds that cover the sky on an overcast day.

Flying through a cloud is no worse than flying through the rain and birds fly slowly enough that they can still turn to avoid a cliff or building that looms out of the gloom. **LV**



Swans are the current high-altitude flying record breakers



QUESTION OF THE MONTH

Plants still garner energy at night from the faint sunlight reflected off the surface of the Moon



Q TOM ENGLAND, LIVERPOOL

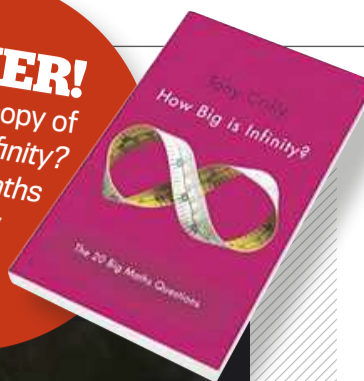
Does photosynthesis occur when moonlight shines on a plant?

A PHOTOSYNTHESIS USES the energy from sunlight to convert carbon dioxide (CO_2) and water into glucose and oxygen. Some of this glucose is used to build plant cells and some is converted back into CO_2 and water to provide energy for the plant's metabolism. The light from a full Moon on a clear night is only about one six-thousandth the brightness of an overcast day, but photosynthesis reactions will still occur, just 6,000 times more slowly. This is too slow to be useful to the plant because it will actually gain less CO_2 from

photosynthesis than it loses from the respiration of its cells. As the Sun rises each day, photosynthesis becomes more and more effective until the plant absorbs just enough CO_2 to keep up with the amount burned for energy. This is called the 'compensation point' and it occurs in the early morning and then again in the late evening as the light levels drop again. Outside of these times, photosynthesis isn't useful to the plant and many plants close their leaves at night so it doesn't disrupt the circadian rhythms that control flowering. **LV**

WINNER!

Tom wins a copy of *How Big Is Infinity?* The 20 Big Maths Questions by Tony Crilly (Quercus)



Q GEORGE BENSON, YORK

If we had to destroy the Voyager space probe now, would it be possible?

A VOYAGER 1 IS the furthest human-made object from Earth, having entered interstellar space in 2012. Voyager 2 is also fast reaching the edges of the Solar System. There is no self-destruct button for either of the Voyager spacecraft. Each still has hydrazine fuel on board and can fire its rockets to change course. Theoretically, mission control could steer the craft on a suicide mission toward an asteroid. But the distances would be huge and no quick way of destroying the probes. **GM**

Q DANIEL CRIPPS, MALVERN

How does a cool compress relieve the pain of a headache?

A A SINUS HEADACHE is caused by inflamed sinus membranes blocking the flow of mucus. Cooling the blood around your head can signal to the hypothalamus in your brain that your core temperature is too low so blood needs to be diverted away from the head to the vital organs. This reduces swelling of the sinuses. But the most common type of headache is a tension headache and any benefit you feel from a cold compress with these is probably just because it feels soothing, which lowers your stress levels. **LV**

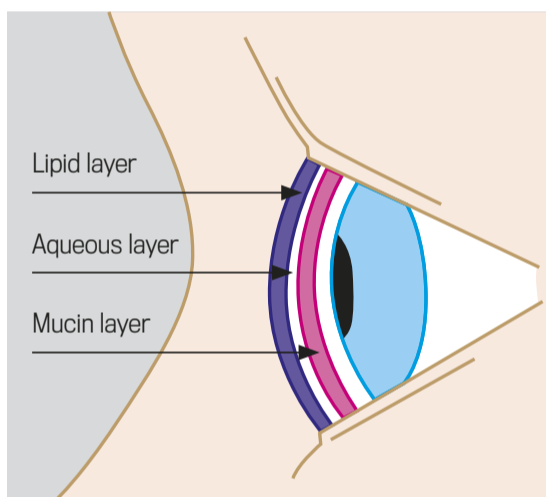
Sinus headache? Slap a cool compress on your scalp



Q CLAIRE THOMPSON, EXETER

Why do we get dry eyes?

A YOUR EYES ARE covered in a thin film of fluid in order to make the surface optically smooth. It is secreted by the cornea and the lacrimal glands in the corner of your eyes. Dry eye, or keratoconjunctivitis sicca, happens when you don't make enough tears or you don't blink enough. Blinking is important because the tears can't spread fast enough by themselves to keep up with the rate of evaporation. Driving, reading or staring at a computer screen all reduce your blink rate. Tear production slows as we age, but can also be reduced by damage to the corneal nerves from contact lenses or eye surgery. **LV**



The different layers that keep your eye nice and moist

Q JEFF DOBSON, BY EMAIL

What happens to the energy of light as it crosses the Universe?

The wavelength of the light from these distant stars has been stretched by the expansion of the Universe

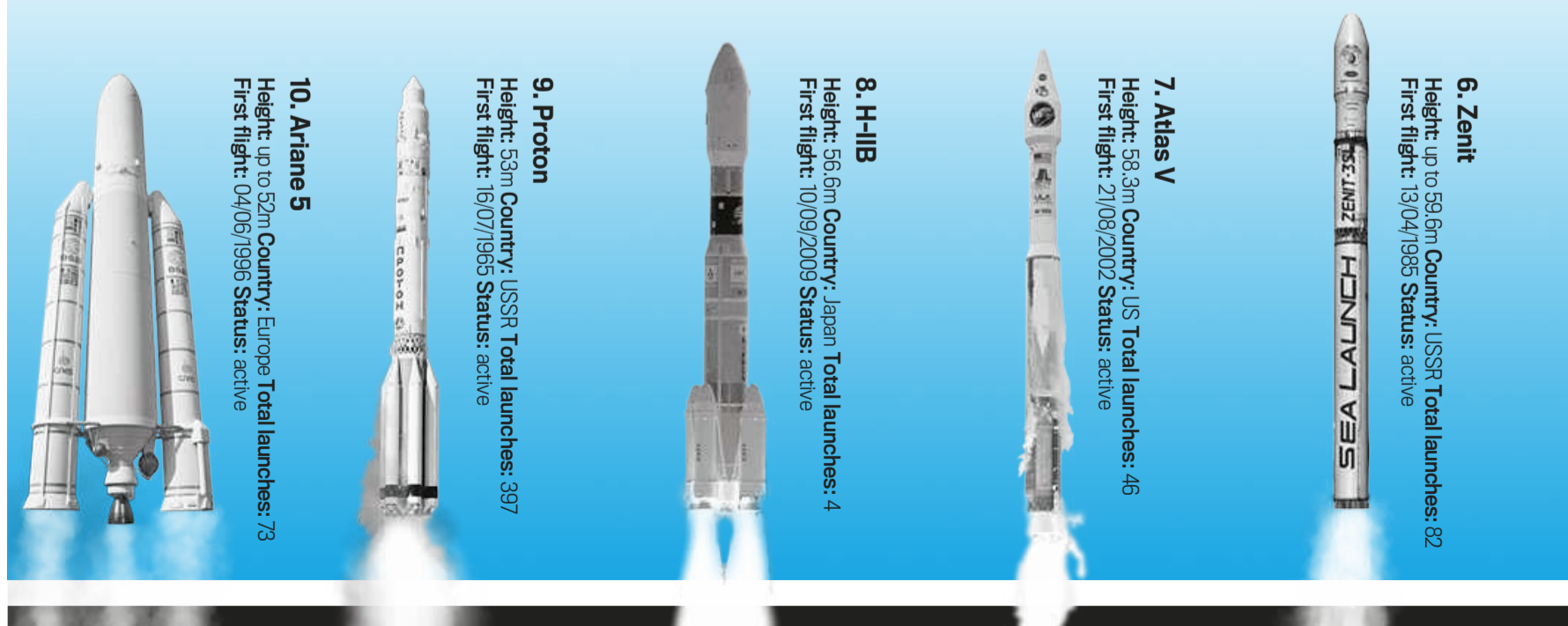
A LIGHT COMING FROM ever more distant galaxies has an ever-longer wavelength, or a 'red shift'. According to physics, that should mean the photons of light have lost energy on their journey. Yet this overlooks the weird physics that kicks in on cosmic scales. In particular, it ignores the fact that the Universe – and thus the very fabric of space and time – is expanding. This literally stretches the light, increasing its apparent wavelength while leaving its energy unchanged.

This explanation is still rejected by some, who argue it's the cosmic expansion that's an illusion, while the energy of light really does decrease

through collisions with particles in its path. This so-called 'tired light' idea is intuitively much more appealing, and can be put to the test. For example, it predicts that distant objects will appear much fuzzier, as the higher-energy photons striking them will be scattered more violently. Yet images of distant galaxies show they're relatively sharp.

On the other hand, the cosmic expansion theory predicts that distant supernova explosions should appear slower than nearby ones, while tired light theory predicts no such stretching of time. Observations of supernovae have confirmed a cosmic 'slow-mo' effect – proving tired light wrong again. **RM**

TOP TEN TALLEST SPACE ROCKETS



Q SARAH MCDONALD, BRIGHTON

What is 'regression to the mean'?



Were Brazil simply regressing to the mean at the World Cup?

A FROM ACCIDENT RATES to the performance of businesses, many things have an average or 'mean' value while still being subject to random variation. For example, a football team will have a typical level of success dictated by the quality of its players and management, but will experience runs of above and below-average results caused by fluke goals, bad refereeing and the like. Over time, these effects even out, so that performance 'regresses to the mean'. Ignoring this can lead to bad decisions which look good, but only for a while. For example, managers may get sacked following a bad run and initially the results improve. But it's nothing to do with the new boss: it's just regression back to the mean, as the random effects behind the run of losses fades away, and performance goes back to the average. **RM**

Q LEN HARSON, HARROGATE

Could we genetically modify wasps to perform bee-like functions?

A MOST WASPS ARE parasitic, solitary insects that have quite different life-cycles to bees. The stripy wasps resemble honey bees because it's an evolutionary advantage for two unrelated stinging species to send the same warning signal to birds and animals that might try to eat them (something called Müllerian mimicry). There are several social wasps – including the European paper wasp and the American yellow jacket – and the adults do sometimes feed on nectar,

like bees. But wasps are only minor pollinators of most plants because their larvae are all carnivorous and so the adults spend most of their time foraging for insects, not visiting flowers to gather nectar.

By the time you genetically engineer a wasp to give it the enzymes to turn nectar into honey, the wax glands to make a waterproof honeycomb and larvae that can be fed honey instead of insects, you have created a bee. **LV**



Don't be fooled, it may look like a bee, but this is a wasp – the bane of beer gardens the world over

1. Saturn V

Height: 110.6m Country: US Total launches: 13
First flight: 9/11/1967 Status: retired

2. N1

Height: 105m Country: USSR Total launches: 4 (all exploded) First flight: 21/02/1969 Status: retired

3. Delta IV

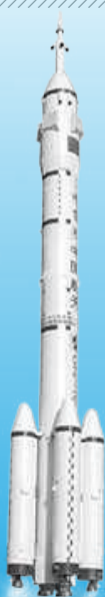
Height: 72m Country: US Total launches: 26
First flight: 11/03/2003 Status: active

4. Falcon 9

Height: 68.4m Country: US Total launches: 9
First flight: 04/06/2010 Status: v1.1 active; v1.0 retired

5. Long March 2F 'Shenjian'

Height: 62m Country: China Total launches: 11
First flight: 19/11/1999 Status: active



Q JACK MOORE, BY EMAIL

At what point can robots be considered sentient?



A IN JUNE THIS year, Reading University hailed a 'historic milestone in artificial intelligence' when it hosted an event in which a chatbot called Eugene supposedly passed the Turing Test. Judges were fooled a sufficient number of times into thinking that Eugene was human, a requirement to pass the test. Reading's announcement was widely criticised, partly because the chatbot was imitating a 13-year-old non-native English speaker, thus setting a rather low bar for a text-based conversation. Not even the Reading University researchers argued that the machine was sentient.

So what might a more rigorous test for sentience involve? Perhaps it could be a development of machine vision. Present-day image recognition can identify an individual's face. It detects the face but that's different from saying it sees it. A test for sentience might require the machine to discuss objects and people in context. **GM**

In Numbers

3 million km²

is the area Australia hopes to convert in the north of the country into a gigantic 'food bowl' to double agricultural output by 2050.

Q JOHN THORNLEY, BY EMAIL

How are we so good at sensing tension between two people?

A WE USE ALL our senses. We observe facial expressions and body language, listen to how people speak as well as what they say, and even use smell and touch to pick up their emotional state. Some of this skill is innate: we have hard-wired facial expressions and bodily responses to fear, disgust, or aggression, and are good at recognising these in other people. Much of it is learned: when we see two people trying hard to disguise their difficulties we may recognise the way they are speaking or the distance they keep from each other from our own



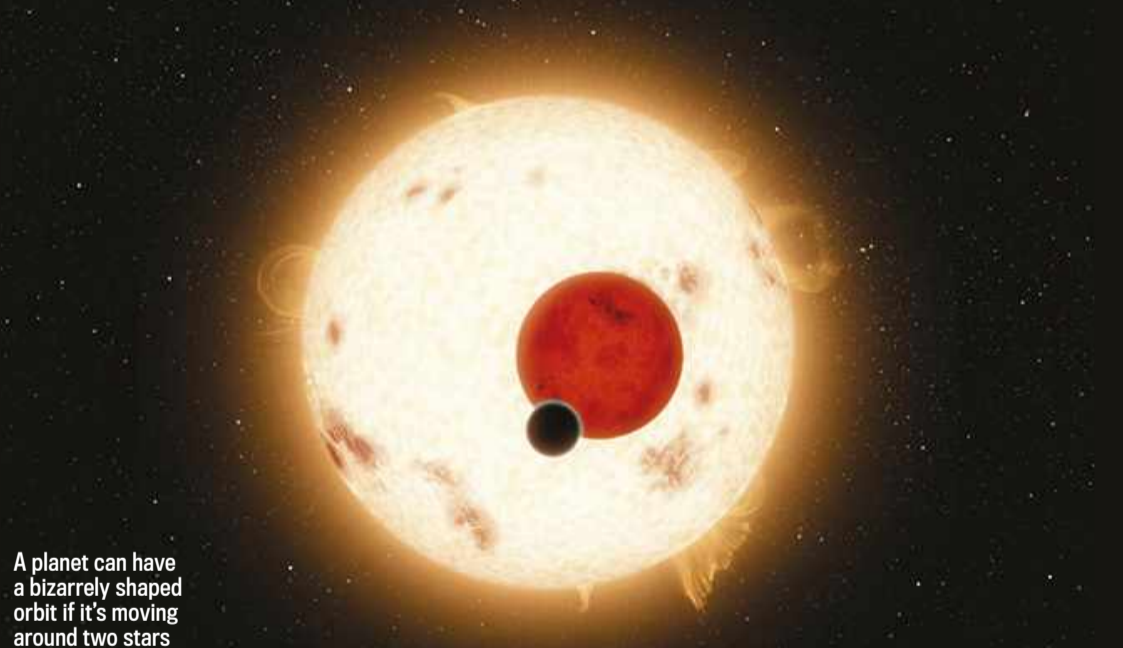
Should have remembered to renew that *Focus* subscription...

experiences or from having seen our friends act that way in the past.

Some people are far better at this kind of social perception than others. Women tend to recognise emotions more easily than men, but everyone can improve their skill by paying attention to their own and others' emotional states. **SB**

Q TIKVAH SIMON, ISRAEL

What shape does a planet orbiting two suns make?



A planet can have a bizarrely shaped orbit if it's moving around two stars

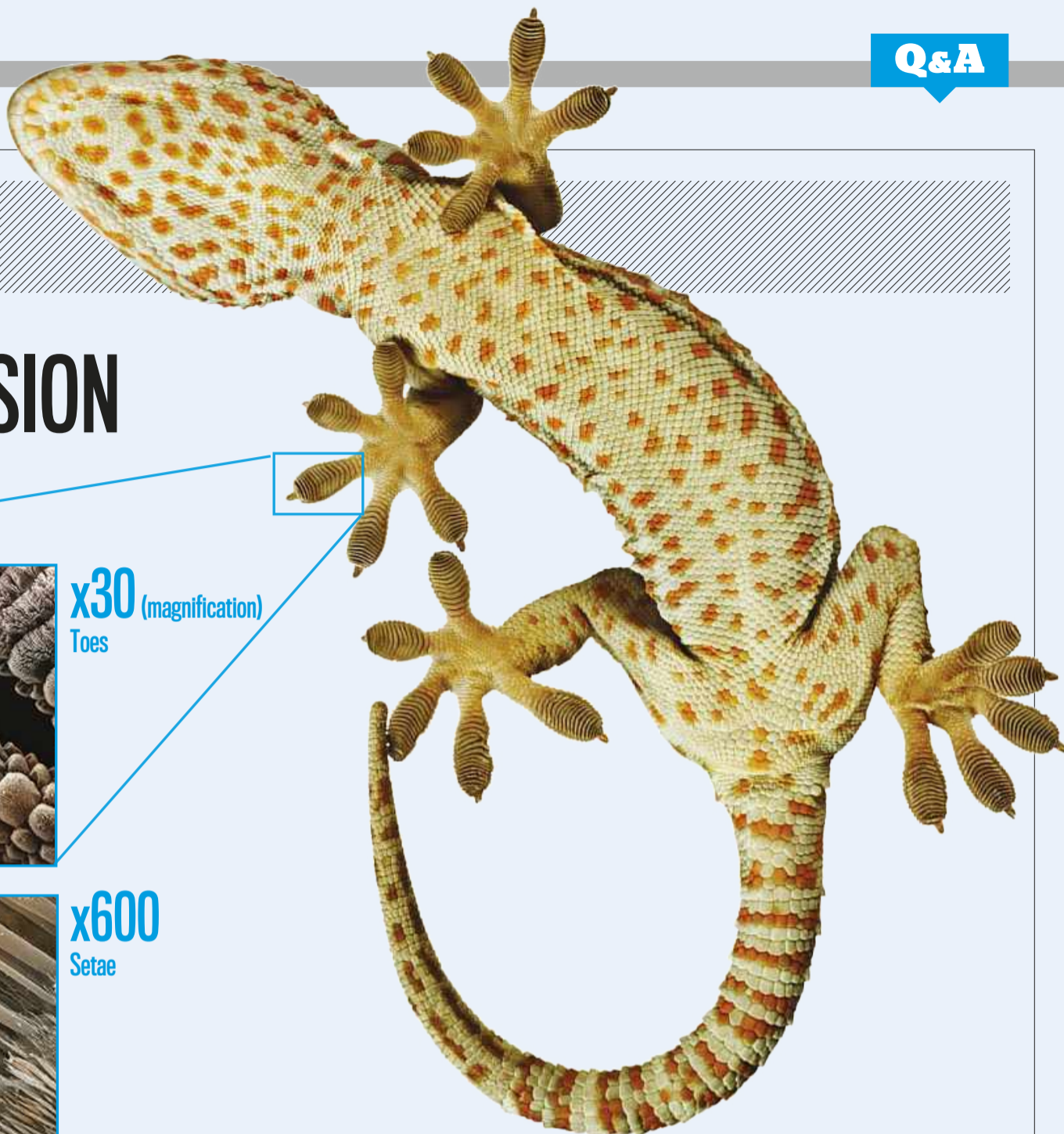
A THERE ARE MANY possible orbital shapes that a planet can make in a binary star system. It depends on the masses of the two stars, their separation, the mass of the planet, its distance from each star and whether it is orbiting one star in the pair or both. At sufficient distances the planet will revolve around both stars in an elliptical orbit. Closer in, the orbit may be squashed into various

shapes that slowly change orientation, much like the patterns you get from a Spirograph. There are even orbits that trace out long sausage shapes or the petals of a flower, or cross periodically between the two stars. Complex orbits such as these may be rare, since many of them are inherently unstable and would soon break down. Figure-of-eight orbits are not possible. **AG**



HOW IT WORKS

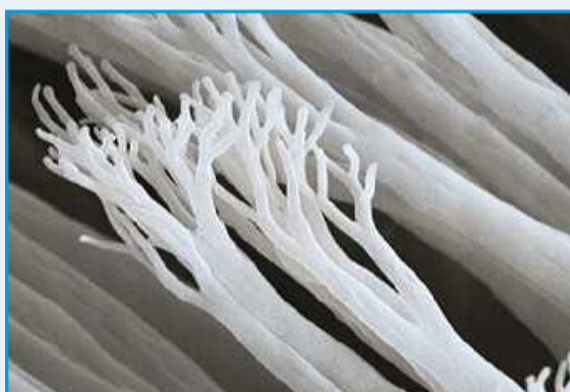
GECKO ADHESION



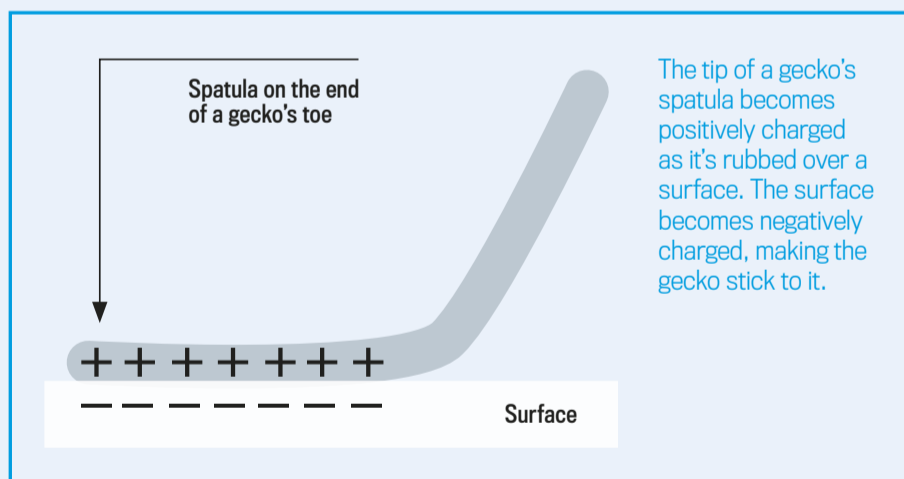
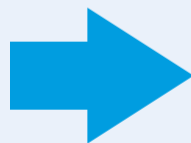
x30 (magnification)
Toes



x600
Setae



x9,170
Spatulas



ZOOLOGISTS HAVE LONG been fascinated by the gecko's Spider-Man-like ability to cling to walls and ceilings. Until recently, geckos were believed to stick to surfaces by making use of two different forces. One is weak van der Waal's forces, formed from the momentary unequal share of electrons between molecules. The other is capillary action, the attractive force that allows kitchen towel to soak up water. Now, scientists have discovered a third.

In July, a team at the University of Waterloo, Canada, found that electrostatic attraction

also plays a role in the reptile's sticky ability. The strong, electrostatic force develops from the stable electron exchange between molecules, and is what makes our hair stand on end and stick to balloons. Scientists discovered that a tokay gecko (pictured top) was using this force by gently dragging its feet across a non-sticky surface and measuring the resulting electric charge. Electron exchange takes place where the tiny spatulas at the ends of each hair-like seta on the gecko's toes make contact with the

surface of the material. This creates a measurable force. The team found that when the gecko's toe pad made contact with a surface, the pad became positively charged while the surface became negative, creating electrostatic attraction.

The strength of the electrostatic charge suggests that this force is the most important for the gecko's adhesive ability, yet the other forces are likely to be important when geckos climb wet, slippery surfaces, where electrostatic bonds cannot form.

Q TIM NELLIS, ROMFORD

Which part of the brain generates free will?



Scientists have been able to detect the brain activity of an action half a second before it's physically carried out

A NO PART! LIKE many scientists, I don't believe we have free will. If the power of thought alone could cause our brains and muscles to act, it would be magic, because every action, every decision and everything we say depends on what happens in our brains and our environment. Since Benjamin Libet's ground-breaking experiments in the 1980s we have known that the brain activity associated with an action is detectable half a second before a person decides to act. Since then, scientists have

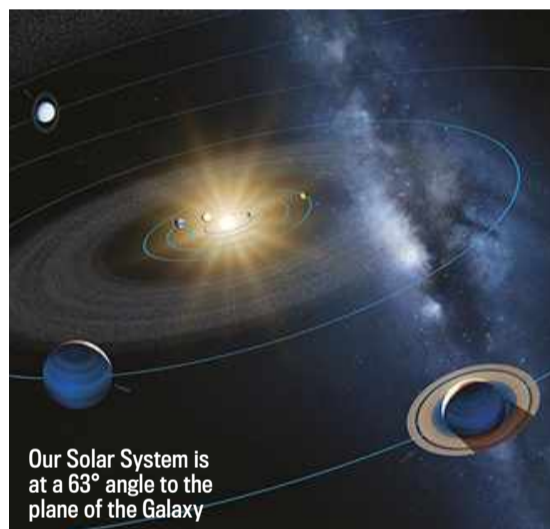
predicted people's decisions from brain scans several seconds before they are made.

This may seem weird, but surely fits with everything we know about how the brain works. Of course there can be randomness too, and recent brain research has shown that random events in a person's brain can also be used to predict what they will do next. But randomness doesn't give us free will. The real challenge seems not how to find the causes of free will – but to learn how to live without believing in it. **SB**

Q SIMON BARTLETT, LEICESTER

Are the planes of solar systems aligned with the plane of their galaxy?

A THE ORIENTATION OF a planetary system orbiting a star depends only on the initial angular momentum of the clouds of dust and gas from which it formed. Since these small motions are completely random, the resulting planetary system can have any orientation. The structure of the star's host galaxy has no bearing at all on how its planetary systems align themselves. Our Solar System, for example, is inclined by about 63° to the plane of the Milky Way. **AG**



Our Solar System is at a 63° angle to the plane of the Galaxy

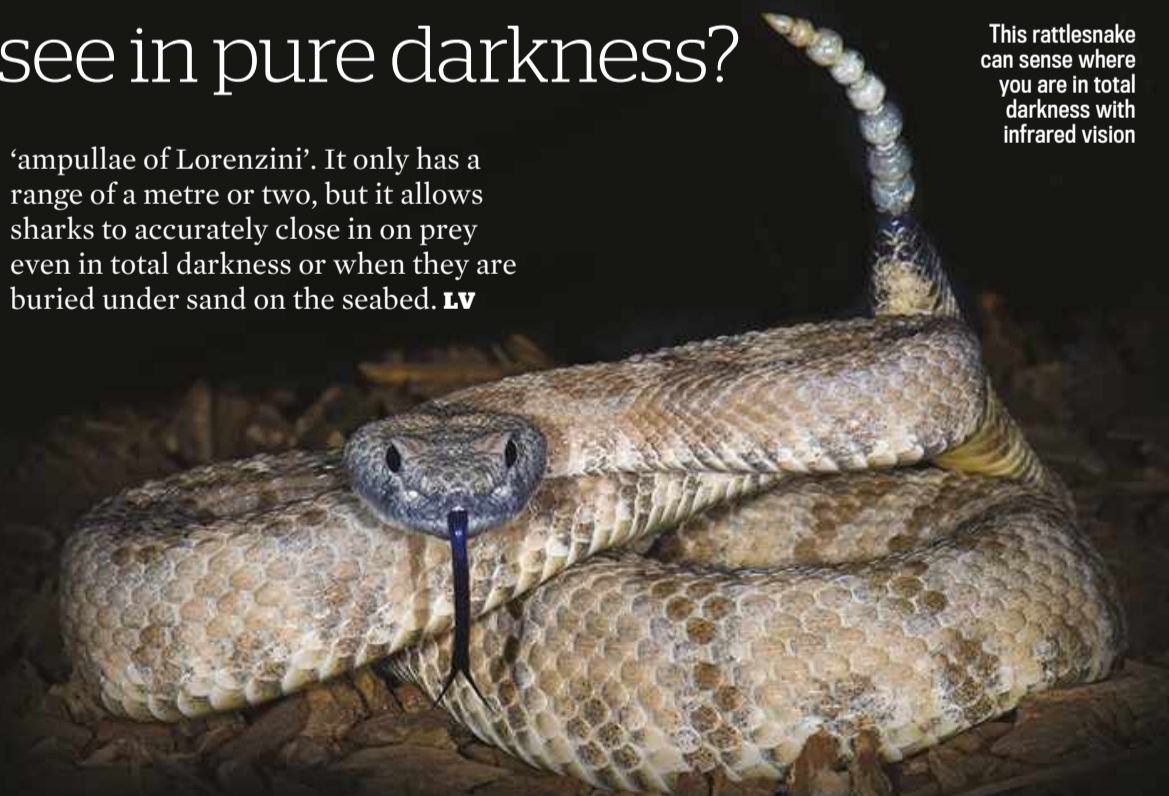
Q LIAM HORNE, NOTTINGHAM

Can any animal see in pure darkness?

A EVEN WITHOUT VISIBLE light, pit vipers, which include rattlesnakes, can sense the infrared light given off by any warm-blooded prey. Their pit organs near the nostrils don't have a lens, so the heat image is fairly blurry. Many insects, including bees, can see into the ultraviolet, but ultraviolet light is never present in nature without some visible light as well, so it's no use in total darkness.

Bats and dolphins 'see' by listening to the pattern of echoes from their high-pitched squeaks, and sharks can sense the tiny electromagnetic field generated by all living things. Electroreception uses special pores around the snout of the shark, called

'ampullae of Lorenzini'. It only has a range of a metre or two, but it allows sharks to accurately close in on prey even in total darkness or when they are buried under sand on the seabed. **LV**



This rattlesnake can sense where you are in total darkness with infrared vision

Can't sleep? Try sitting on the edge of your bed for a while

Q SAM SHAW, ANDOVER

What's the best way to treat insomnia?

A THERE'S NO SINGLE best way but insomnia, and worrying about insomnia, can be a self-perpetuating bad habit. If you don't sleep well it's tempting to watch TV, check your phone, or drink too much alcohol. All these, the experts say, have to change. You need to get plenty of exercise, though not last thing before bed; avoid caffeine after midday; avoid heavy evening meals, and keep alcohol down. Good 'sleep hygiene' includes keeping

regular sleep times and using your bedroom only for sleeping and sex – not for work, email, phone calls, watching TV, or anything else stimulating or upsetting – so your body learns to associate that room with sleep. And if you wake in the night, don't reach for your gadgets or even a book. A simple trick that works for some people is to sit up in the dark on the edge of the bed. You soon get bored and sleepy. **SB**

Q WENDY DARCY, LITTLEHAMPTON

Which animal can perceive the highest pitch of sound?

A THE GREATER WAX moth, *Galleria mellonella*, can hear ultrasonic frequencies as high as 300kHz (humans can't hear anything above 20kHz). The moth uses this ability to listen out for the ultrasonic calls of bats. The highest frequency bat calls are only 212kHz, so the moth clearly has the edge. **LV**



The greater wax moth has an incredible set of ears

WHAT IS THIS?



KNOW THE ANSWER?

Go to sciencefocus.com/qanda/what and submit your answer now!

LAST MONTH'S ANSWER:

Marco Carlo Virgili correctly guessed 'tooth dentine'.

Q ROBERT WEST, CAMBRIDGESHIRE

Why do ears burn?

A BURNING EARS ARE part of the blush response. The skin of our face and ears has more capillaries than other body parts and when we are ashamed, these capillaries open up to bring blood to the surface. This makes us look red and feel hot. The evolutionary reason for this may be that we benefit from showing a group that we are aware of social codes. **LV**



Ears feel hot? You're probably feeling a little embarrassed

NEXT MONTH Over 20 more of your questions answered



For even more answers to the most puzzling questions, see the Q&A archive at www.sciencefocus.com/qanda



HOW TO SWAT A FLY



This month you might find aerial pests trying to colonise your front room. **Timandra Harkness** finds out how to get the upper hand

Illustrations by Robin Boyden



1. KNOW YOUR ENEMY

STRENGTHS:

FLIES ARE AMONG the best fliers in the insect world (the clue is in the name) and the housefly, *Musca domestica*, is no exception. Their huge thorax is a powerful engine that lets them take off from a standing start. That annoying buzz

is a single pair of wings flapping 200-300 times per second, which makes them fast and manoeuvrable. They are so agile that, like a fighter jet, they are unstable in the air – but our experts agree that no scaled-down fighter jet would ever beat one in a dogfight. So going after a fly with a rolled-up copy of *Focus* is like taking on a Harrier Jump Jet with a Medieval trebuchet. The scale and construction of a fly's body makes it annoyingly resilient. You could clap a fly between your hands, only to have it emerge unharmed.

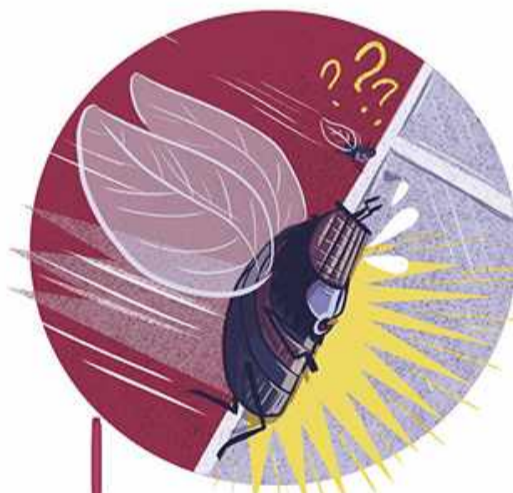
Their eyes are very different to ours. Flies have compound eyes made up of hexagonal sections called ommatidia, each of which has a lens and a receptor. This makes them very sensitive to movement, because each receptor can register movement as an object appearing in, or disappearing from, its field of vision.

Flies also detect odours far better than we can, so they know when your food is starting to decompose before you do. The apparently random flight path that makes

them such an elusive target is probably the result of homing in on a faint scent.

WEAKNESSES:

There is no evidence that flies can learn. That's why they will buzz against a closed window for hours until they die, instead of finding their way out of the open one.



2. SURVEY THE BATTLEFIELD

FLIES ARE ATTRACTED to things they can eat – including our food, rotting matter and excrement. Females are also attracted to suitable places to lay eggs – again, mostly food and excrement. Light attracts them – windows by day, lamps, flames and light bulbs at night. So strategically turning lights on or off can lead your enemy to exactly where you want the showdown to happen.

3. GEAR UP

BECAUSE OF THE relative viscosity of air to a fly, traditional weapons like a rolled-up magazine will just push it to safety – like trying to pick up something that's floating in your drink, only to find it slips away from your fingertip.

That's why a perforated swatter can be more effective, as it allows some of the air to move through the attacking surface, while disrupting the airflow in a way that may hamper the fly's evasive action.

You could also try a powerful vacuum cleaner to suck the fly into oblivion. Dr James Logan, of television's *Insect Dissection* and the London School of Hygiene & Tropical Medicine, says "The most effective way to kill a fly is to spray it with a toxic chemical." Unfortunately, they rapidly develop resistance even to the current insecticide WMDs, pyrethroids.

If you like your murder weapons natural, many essential oils have been found to kill houseflies, including orange, cinnamon, nutmeg and clove. But you may find it confusing to have a house that smells of mulled wine all year round.

However, the optimum weapon recommended by Dr Logan is a flick with a damp towel.

4. WINNING STRATEGY

FLIES FATIGUE QUICKLY, so you could just chase it around till it gets tired. But that's undignified, so here's our two-stage plan:

STEALTHY APPROACH:

Shadows or sudden movement will trigger evasive action, so keep the light in front of you and move slowly and steadily towards the enemy with weapon poised, till you can see the multicoloured facets of its eyes.

SUDDEN AND RUTHLESS ATTACK:

The key to victory is the supersonic strike. Not only will there be no buffer of air to push your victim aside, the shock wave will destroy its tiny insect body without needing a solid surface against which to strike.

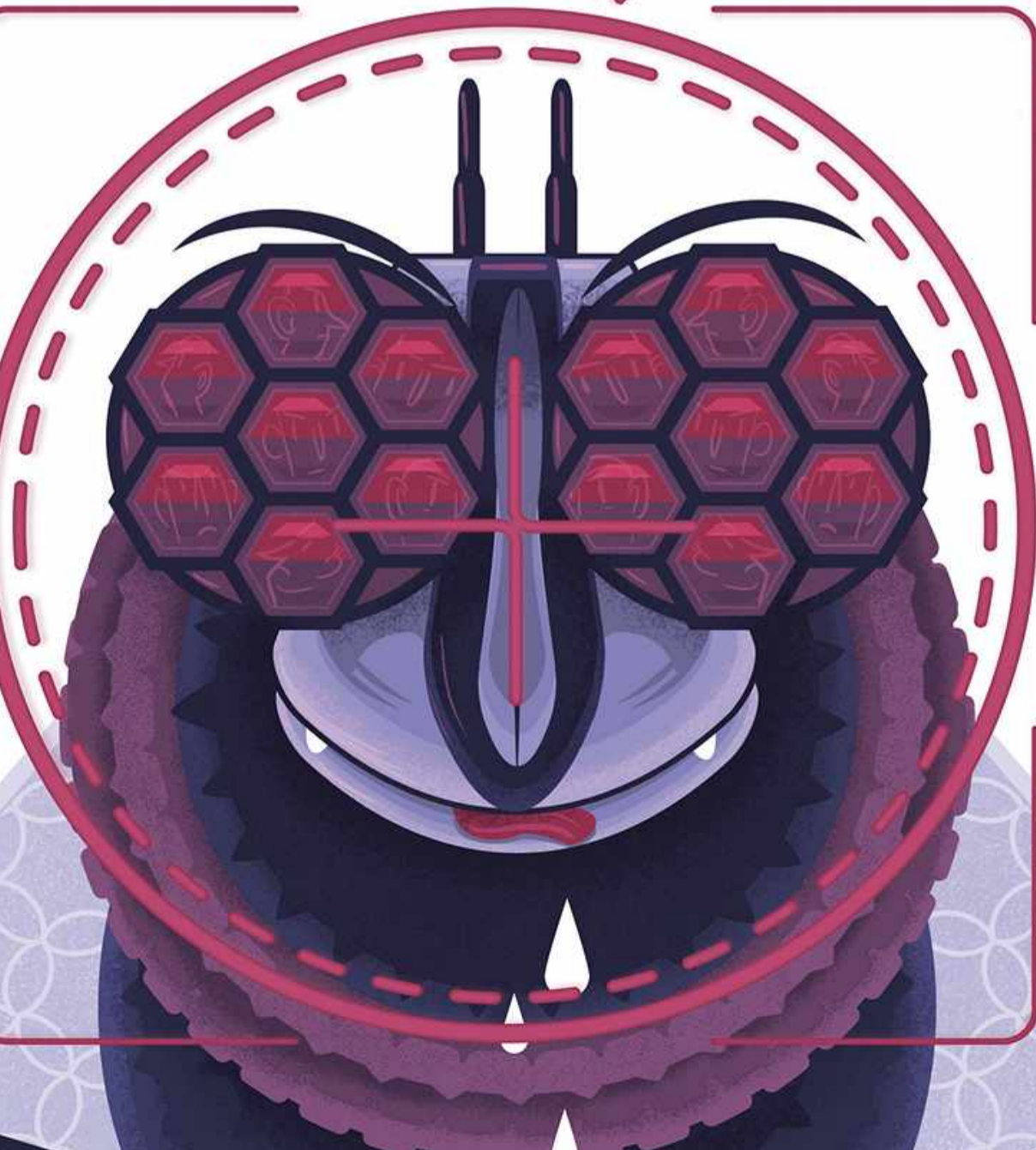
According to researcher Leon Vanstone of the University of Texas at Austin, this is the key to Dr Logan's successful damp towel attack. Cracked like a whip, the end of the towel will attain supersonic speeds – above 1,225km/h (761.2mph) – and send an audible shockwave to explode the fly in mid-air.



5. EXIT STRATEGY

EVERY MILITARY CAMPAIGN needs to be part of a longer-term policy, or you could be chasing flies with a damp towel for years to come. Keeping food, or anything that a fly would eat, out of reach is a start. But flies will also come in search of moisture, or even the salt on your skin. So you need to actively repel them. Essential oils of star anise or peppermint have some deterrent effect on flies, but they may do the same for you. In regions where insects carry potentially fatal diseases, nets treated with DDT effectively keep them away. ■

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze



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THE WAR ON SMOG

As airborne pollution rises in cities around the world, millions of lives are increasingly at risk. **Jheni Osman** looks at some innovative solutions...

YOU KNOW THERE'S a problem when the giants start coughing up. Panasonic now pays employees compensation to relocate to Beijing, because the city's air quality is so bad. And it's not just the capital that's smothered in smog. China has promised \$277 billion to deal with the problem in cities across the country.

Face masks have become a fashion necessity for Chinese urbanites. The police have even been issued with nose plugs to keep the pollutants out. But these are short-term measures. How is the rest of the world going to tackle this dangerous problem? Fortunately scientists are working to clear the air.

It's not just the Red Dragon that's battling smog. As



➔ populations boom in cities like Delhi, emissions soar. Hot, sunny conditions cause ozone concentrations to reach unhealthy levels. And without rain to disperse particles and wind to blow them away, residents suffocate under a stagnant layer of smog.

Mexico City is choking. Bulging with bodies, sweating under tropical heat and trapped in an airless basin, surrounded by mountains soaring 2,000m above, its topography and dense population create the perfect storm for smog build-up. "Cities in valleys, or surrounded by mountains, are often more susceptible to smog. They're sheltered from winds, thus reducing the dispersion of pollutants," says Met Office scientist Marie Tilbee. "In addition, a sharp increase in temperatures through the lower parts of the atmosphere during the night can act like a lid on the pollution."

"Ozone high up in the atmosphere protects us from the Sun's UV rays, but near the surface it's dangerous"

Even European cities like Rome and Paris are suffocating in smog. In a drastic attempt to curb car use to cut air pollution, Parisians whose car number plates ended with an even digit were banned from driving for one day in March. By midday, police had handed out around 4,000 on-the-spot fines. But it worked – the smog subsided.

Britain isn't immune. For days in April, a smog cloud gripped the UK. On the 10-point scale for measuring air quality from the Department for Environment, Food & Rural Affairs (DEFRA), UK levels reached as high as 10. A 10 means you should reduce your physical exertion, especially outside. Some schools banned pupils from playing outdoors, ambulance services reacted to thousands more 999 calls, and 1.6 million suffered an asthma attack.

The term smog – an amalgamation of 'smoke' and 'fog' – first surfaced in the early 1900s. The culprit was coal. Burning it left a grim, grey stain on the skyline of industrial cities around the developing world. This is what's known as 'classic smog'.

"Photochemical smog requires neither smoke nor fog," says Tilbee. "It's caused by tiny particles that form in the atmosphere when emissions of nitrogen



and sulphur oxides from industry and traffic react in the presence of sunlight with volatile organic compounds (VOCs) from petrol, paints and many cleaning solvents." All these particles undergo complex reactions with sunlight to form secondary pollutants. These then combine with the primary emissions to form photochemical smog, which includes ground-level ozone.

Ozone is an inorganic molecule consisting of three oxygen atoms that's formed by the action of ultraviolet light and electrical discharges. High up in the atmosphere it protects us from the Sun's UV rays but near the surface it's dangerous, damaging lung tissue – a real threat to sufferers of respiratory illnesses like asthma. Poor air quality causes an estimated 2.6 to 4.4 million premature deaths globally every year. The main cause is two types of particle, or 'particulate matter' (PM): PM10 and PM2.5. "PM2.5 are only 2.5 micrometres wide, so

Clockwise from top: A rocket is prepared for launch to seed clouds in China; women wear face masks in Beijing; Euphore's smog simulation chamber in Valencia enables scientists to test ways to disperse dirty air; architects envision climate controlled domes for smog relief



they're small enough to penetrate deep into the lung tissue," says Professor Martin Williams of King's College London. "They can exacerbate respiratory problems like asthma, and are linked to deaths due to heart attacks."

A BREATH OF FRESH AIR

Help is at hand. Back in China, insurers have cashed in on the smog issue, offering pollution insurance. But if you don't fancy delving into your wallet so you can wheeze-away your retirement in relative peace, don't worry, serious smog research is underway. At the Euphore research facility in Valencia, Spain, scientists perform tests on artificial smog. And China has just given the go-ahead for a similar 'smog chamber', 50 per cent bigger than Euphore's. But in the meantime, inventors are coming up with all sorts of grand solutions.

1.6 MILLION

people suffered an asthma attack in the UK during a period of dangerous smog levels last April

A HOT ISSUE

How climate change is making smog worse

NORMALLY OUR ACHILLES' heel, Britain's rainy climate helps to scrub some pollutants from our skies. But global warming is altering atmospheric circulation and precipitation patterns, which means lighter winds and less rainfall for some regions of the world. But how does global warming affect the conditions that help smog to build up?

A recent study published in *Nature Climate Change* looked at the frequency and duration of so-called 'air stagnation' events. "Stagnation events occur when conditions limit pollutant dispersal," says Dr Daniel Horton of Stanford University, who co-wrote the report. "This happens when near-surface winds are light, upper-atmosphere winds are light, and there is little or no precipitation."

If greenhouse gas concentrations continue to rise at their current rate, global temperatures will increase by 4°C by 2100. Using global climate model projections, the team found that, by the end of the century, air stagnation areas could cover about 55 per cent of the global population. Some regions could experience, on average, an increase of up to 40 days of stagnation every year. This would obviously have a huge impact on public health.



A policeman wears a mask due to smog in the '60s; could climate change mean we see this more often?

London-based architects Orproject have proposed creating climate-controlled giant bubble-shaped domes in Chinese cities. Still at a conceptual stage, residents could hide away in these purified sanctuaries for a breath of fresh air. Meanwhile, artist Matt Hope has invented an air-purifying bike. His ingenious design uses a pedal-powered generator to work a home-made air purification system. This cleans the air before sending it up a hose to a mask for the rider to breathe.

Dutch designer Daan Roosegaarde came up with a similar solution, but on a larger scale. Peering out of a Beijing hotel window a few years ago, Roosegaarde realised that, unlike the previous day, the CCTV building was hidden by a veil of smog. Spotting a design challenge, he set to work to find a solution. The result – an electronic vacuum cleaner.

Far-fetched as this sounds, it's being backed by the mayor of Beijing, who wants to bury the



➔ device beneath grass in a new park. The current prototype uses copper coils to create an electrostatic field that attracts smog particles, creating a void of clean air about a metre wide around the device. “It’s a similar principle to a statically charged balloon that attracts your hair,” explains Roosegaarde. “If you apply that to smog, you create a field of positive ions that literally attract the smog on a PM2.5 level. This is the best way to clean air in a safe and energy-friendly way. It’s already used in hospitals. We’re just building the largest one in the world – outdoors.”

From smog suckers to smog seeders, ‘Cloud seeding’ has been used in the past to create

“Unmanned aerial vehicles have been used in the war on smog. They spray chemicals to freeze atmospheric pollutants”

artificial rain. At the 2008 Beijing Olympics, the technique was used in an attempt to deliver clear skies for the opening ceremony. It works by silver iodide particles being fired via rockets into clouds, where the particles act as points for liquid water to freeze around before falling to the ground. Reports now suggest that China plans to use cloud seeding to remove smog, as rain helps disperse air pollutants.

Fixed-wing unmanned aerial vehicles have also been used in the war on smog. They spray chemicals at height to freeze atmospheric pollutants, causing them to fall to the ground. Now, the Chinese government is planning to test a new drone design. By hanging the vehicle below a parasol, it’ll be able to carry more chemicals (700kg) and have a larger range (up to 5km) than before.

CLEAR SKIES

Of course, all these inventions are still running (riding or flying) away from the over-arching smog issue. In reality, we just need to reduce our emissions. “Cloud seeding to create artificial rain is a blunt instrument. And you’ll have to do an awful lot of Hoovering to clean air with the electric vacuum device! Plus, these technologies will produce more emissions,” says Prof Williams.

SMOG

Levels of particles in the air are rising around the globe and are having a serious effect on our health

PM2.5

Particles with a diameter of 2.5 micrometres or less

PM10

Particles with a diameter of 10 micrometres or less

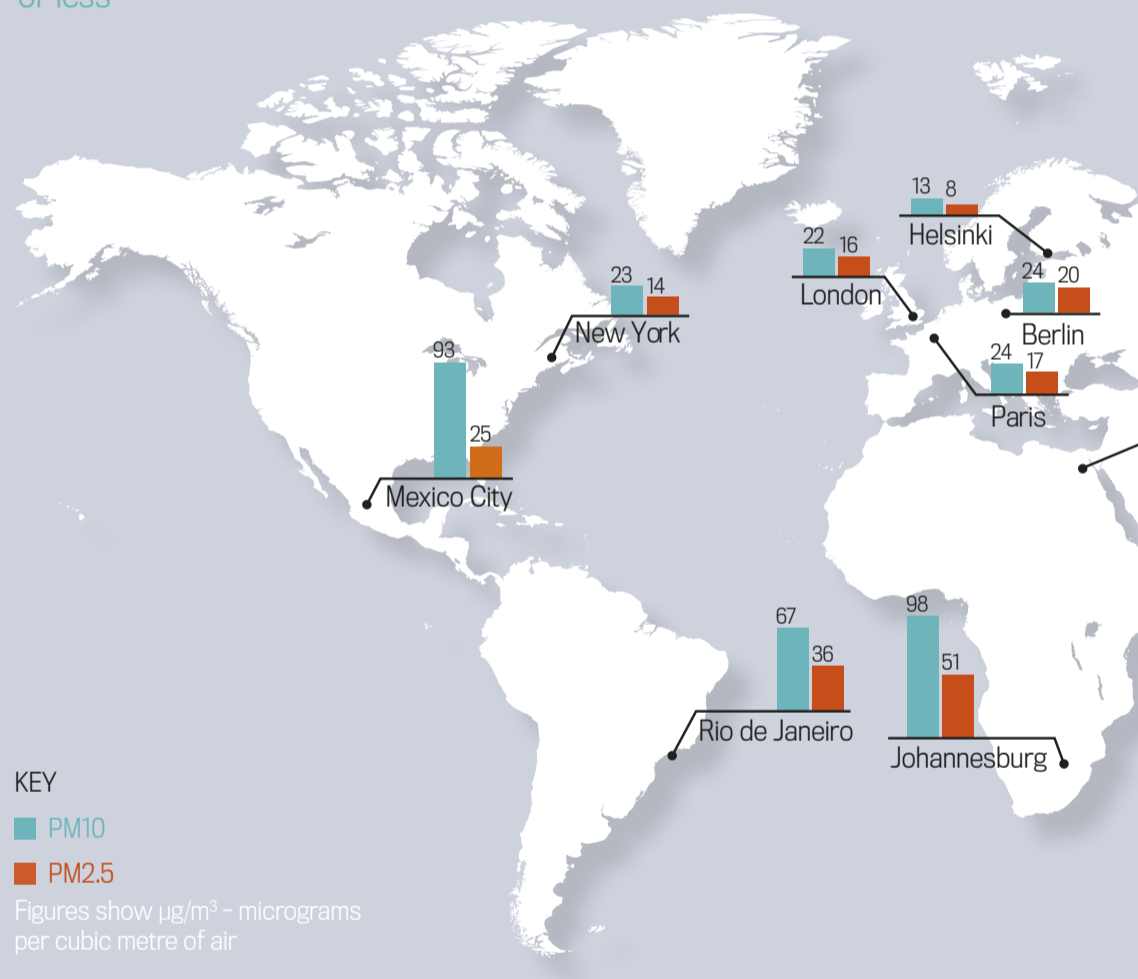
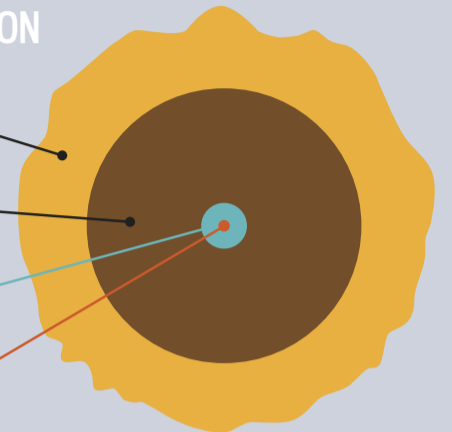
SIZE COMPARISON

Grain of sand

Human hair

PM10

PM2.5



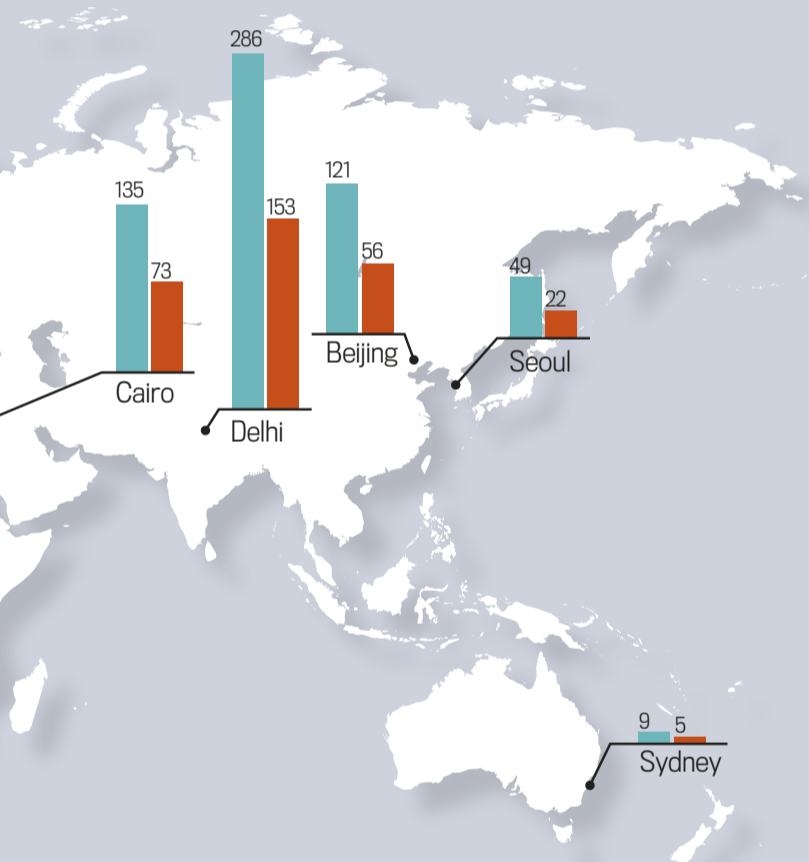
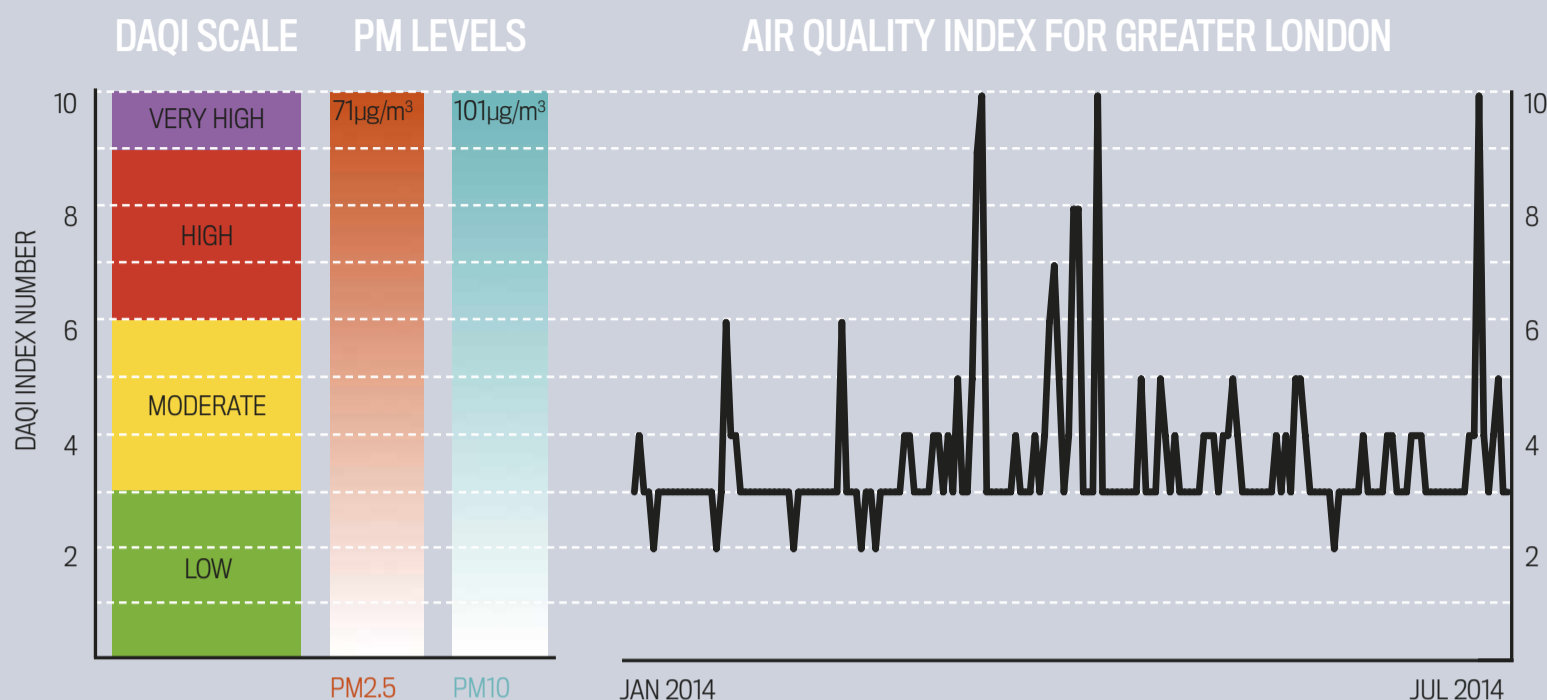
10

is the maximum pollution level that DEFRA says London and the southeast of England reached in April, with dangerous concentrations of particles and pollutants in the air

“You’re better off minimising your emissions from transport by walking or cycling, using clean technology, electric cars and hybrids – and using petrol cars over diesels.”

UK tax policies have encouraged people to buy more diesel cars in the last few years. In 2000, only 14 per cent of new cars sold in Britain were diesels, but by 2010 it was almost 50 per cent. Diesel cars produce more nitrogen dioxide than petrol vehicles, and their average power output has increased by about 50 per cent in the last two decades. Nitrogen dioxide emissions from a diesel are directly proportional to the power output. The more power you squeeze out of a diesel engine, the hotter it

DEFRA's Daily Air Quality Index (DAQI) tells you the levels of air pollution. The index is numbered 1-10 and divided into four bands, low (1) to very high (10).



WHAT SMOG DOES TO YOUR BODY



BRAIN

Exposure to pollutants has been shown to cause cognitive decline, with particles causing neurones to degenerate.



LUNGS

Smaller particles can accumulate in the lungs causing inflammation, while some also enter the bloodstream.



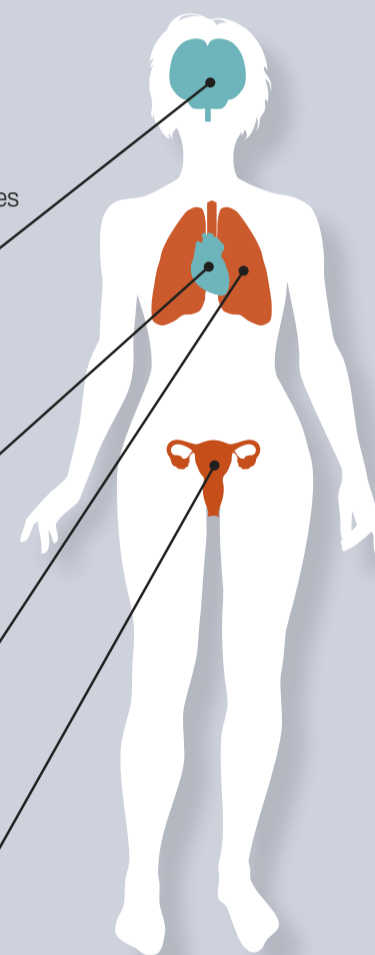
HEART

High levels of pollution are associated with an increased risk of stroke and heart attack.



REPRODUCTION

Pollutants can cause toxicity levels to rise in the placental blood, which can harm the foetus.



burns, so the more air you need, forming more nitrogen dioxide.

A recent government report admits that despite its previous plan to meet EU standards by 2010, air quality in some of the UK's main cities is unlikely to do so before 2030. But Prof Williams is more hopeful: "Vehicle exhaust emission regulations are now so tight that the level of some pollutants should reduce, meaning air quality overall in the UK should improve in the next decade. But EU standards will still be difficult to achieve without further action," says Prof Williams. "The additional problem is that ozone may not go down. It's a pollutant that's not emitted directly but is formed from a complex

1.3
MILLION

early deaths a year could be avoided by 2050 if countries switch to clean energy supplies

series of chemical reactions in the atmosphere. Consequently the ozone we measure in the UK could have resulted from emissions anywhere in the world. Plus, climate change, causing hotter summers, may exacerbate the formation of ozone."

So it seems that despite our best efforts, even if emissions reduce, smog levels could stay the same due to global warming. Better invest in that air-purifying bike then. ■

JHENI OSMAN is a presenter, science writer and author. Her books include *The World's Great Wonders* and *100 Ideas That Changed The World*

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THE FUTURE OF GADGETS

TECH HUB

THIS MONTH

JUST LANDED

Celestron NexStar Evolution 8
p86

ULTIMATE TEST

Google Glass & Moverio BT-200
p89

EDITED BY DANIEL BENNETT

ON THE HORIZON

GE CALORIE COUNTER



Food scanner that
tells you what
you're eating

WORDS: DANIEL BENNETT
Gereports.com

PUTTING together a list of tech commandments, you'd surely have 'Track thyself' near the top – probably swiftly followed by

'Tweet thy dinner'. In fact, activity trackers are *de rigueur* these days, and if you look around you'll find few wrists not sporting some kind of fitness watch and even fewer smartphones without some kind of step-counting app.

This kind of tech is great for keeping your inner couch potato at bay. But ultimately if your goal is to lose weight it has one crucial flaw. These gadgets only track the amount

of calories you're taking out of your body. But as anyone who's serious about losing weight knows, that's only half of the equation.

The other half is how many calories you're putting in (or stuffing in, if you're anything like me). It's an oversimplification, but basically weight loss = calories out > calories in. The problem is that while we've got hundreds of gadgets for working out how many





The prototype of the calorie-counting plate is put through its paces

→ calories we're taking out of our system, we don't have any that reliably tell us how much we're putting in.

So at General Electric (GE), one of its researchers, Matt Webster, and scientists from Baylor University have been working on a solution: a device that will calculate the calorific content of any plate of food put inside. It manages this feat by sending microwaves through the food and monitoring what is received by sensors. When microwaves hit fat and water molecules, they bounce back with a unique signature. Detectors are able to use this information to precisely measure the fat and water content of your meal.

The rest is a matter of deduction. A computer is fed this data and assumes the rest of the food has a pre-defined amount of sugars, carbs, proteins and other ingredients. It seems like a blunt tool for the job, but at the moment GE claims its scanner can determine calorific content to within 10 per cent, though that's only based on scanning liquid mixtures. In the future you might tell it roughly what's inside – eg rice, cake, meat etc – so the device can make its calculations more accurately.

Either way, the technology is in its infancy right now, and while Webster works on improving the reliability of the scanner, GE is also working out how it'll look and work. Right now, the prototype is a rather unappealing-looking aluminium box – it's not something you'd want to cram your sandwiches into. But the goal, says Webster, is to create a "push button device that you could see in every kitchen". To that end, GE has mocked-up the concept pictured, which would simply scan whatever is plonked beneath it. Though really, it's not hard to imagine finding it integrated with that other common kitchen appliance that already fires microwaves into our food.

And like all good gadgets these days, it's likely to be fitted with obligatory Bluetooth connectivity. This will let you plug the data from your scanner into your fitness app, which means you might finally be able to work out whether or not you're really losing weight.

DANIEL BENNETT is the reviews editor of *BBC Focus Magazine*

TECHOMETER

WHAT'S HOT

KARBONN A50S

This new smartphone from India will cost you 10 times less than a new iPhone 5S or Samsung Galaxy S5. It runs Google's Android operating system and is powered by a 1.2GHz processor and 512MB of RAM, which is enough to run most simple apps. Better yet, it can accommodate two SIM cards at once so you can easily switch to local networks when abroad. It costs just £26 and postage will be around £20, but since it's so cheap there's no duty fee.



WHAT'S NOT

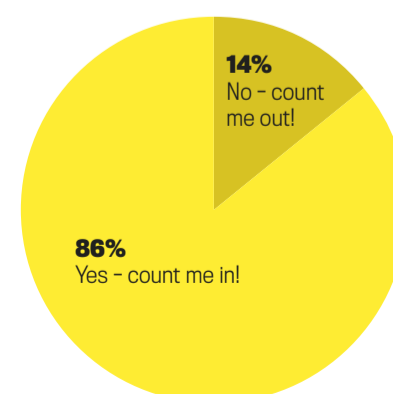
ANDROID APPS

Half of the most popular Android apps have built-in security flaws according to Codenomicon. They're the result of developers using old code from open source software libraries to build their apps. This means they're copying old frailties into new software. The company found that 1 in 10 apps sent a device's location to a third party and one even sent the user's mobile number to an ad network.



READER POLL

Would you use a calorie-counting plate?



THE NEXT BIG THING

SMART GLASSES

With Google Glass now available in the UK and rivals such as ChipSiP's SiMEye smart glass kit showing promise, it is looking more and more likely that we'll soon be surrounded by people sporting network-connected spectacles. Life is going to get a lot easier if you can afford the hardware. I typically pull my phone out of my pocket a hundred times a day just to read a text, take a photo or look something up, so having those services available instantly is going to be a real help.

Glasses will be another device monitoring my location and my activity, of course, but my smartphone and fitness tracker do that already, and we seem to be adapting to a world where Apple, Google, Nike and Fitbit know how many steps I've taken and where I am each day. But we may be less happy being photographed, filmed and recorded all the time. There is a real difference between a smartphone camera in my jacket pocket, taken out and wielded from time to time to catch something interesting, and a smartglass camera at eye level, potentially capturing everything I see as I walk past.

This is especially acute if many people are wearing similar devices, because they turn every space into a monitored zone, recording at far higher resolution than the CCTV cameras we have become accustomed to.

The dangers of having unwanted images or video posted on Facebook or YouTube are real. But there's another wrinkle here: earlier this year the UK Government rushed through the Data Retention and Investigatory Powers Act, forcing phone companies and internet service providers to retain 'communications data' relating to phone calls, emails and social media for a year.

The stream of images, sound and video coming from millions of connected devices will be a far more comprehensive record of daily life than CCTV or the media, and I can imagine the police arguing that they should have access to it. How would you feel if you knew that every pair of camera-equipped glasses in a café fed a data store that could be freely accessed by the police? Or if your own location data showed that you were nearby when a crime was committed and so you received

a warrant requesting the video you'd recorded?

Wearables are mostly obvious, but once they are pervasive then we stop noticing them, just as we've largely stopped noticing CCTV cameras on trains and buses. George Orwell imagined a telescreen in every room, watching the Party faithful and keeping them in line. Wearables offer the prospect of a camera

on every forehead. Yet I suspect that, as with Facebook's data collection or Google's desire to know every aspect of its users' lives, we will embrace the convenience of smartglasses and discount the risks.



BILL THOMPSON contributes to news.bbc.co.uk and the BBC World Service



FROM THE LAB

The device that could cure the debilitating ear-ringing of tinnitus

WHAT IS IT?

The Serenity System is a surgical implant that stimulates a nerve entering the brain to help relieve ear-ringing tinnitus. It's a condition that's reported to affect 10 per cent of people in the UK, and experts believe that figure could rise with people using loud earphones more than ever.

HOW DOES IT WORK?

Like a lot of cutting-edge neuroscience,

the researchers aren't entirely sure. The implant stimulates a nerve called the vagus nerve. This is connected to the brain and travels deep into many of the body's systems. Neurostimulation of this network has already helped scientists treat symptoms as varied as depression, obesity and seizures. In the case of the Serenity System, when this nerve is stimulated alongside an audio signal that interferes with the high-pitched whine of tinnitus, it creates lasting relief from

the symptoms. MicroTransponder, the company behind the tech, believes that stimulating the vagus nerve makes the brain better able to perceive sounds, and therefore more susceptible to the audio therapy.

WHEN CAN YOU BUY ONE?

Sadly for tinnitus sufferers, there's a bit of a wait. The technology has just undergone its first successful trial so it's likely to be a year or two before it lands on our shores.



Serenity System has been heralded as a possible cure for tinnitus



JUST LANDED: CELESTRON NEXSTAR EVOLUTION 8

SEEING STARS

It's a Wi-Fi controlled robotic telescope you command from your smartphone. Astronomer Paul Money takes it for a spin

What is it?

Celestron's NexStar Evolution 8 is an 8-inch telescope with high-quality optics on a computerised mount. It also comes with its own integrated Wi-Fi network and power supply, along with two eyepieces for viewing the treasures of the night sky.

How does it work?

The mount produces its own Wi-Fi network called SkyQ Link that you can access with a

Select celestial wonders from the SkyPortal app to automatically move the telescope to view them



smartphone or tablet. All you have to do is download the free SkyPortal app (Android and iOS versions available). This allows you to take control of the telescope, so that it becomes a real-life planetarium.

A little set-up is required before you start. First a star diagonal (a 45° mirror) is inserted into the eyepiece holder to give you a more comfortable viewing position. You then have to aim the telescope via the app's on-screen controls at three stars to perform a star alignment. But don't worry, you don't need to know their names: the technology works out which stars you've used. Once done, you can then command the telescope to point at any celestial object above your horizon at the time by simply selecting them from the app.

Is it easy to set up and use?

Clear instructions are provided to get it all up and running. Ideally, you need to level the tripod with the in-built bubble level on the mount for the most accurate results. We found the app quite easy to use and it seamlessly connected to the scope's Wi-Fi. Selecting the telescope icon in the app gives you the option to connect and align, and once this was done we tapped on an object of interest and selected 'GoTo' to make the scope move to the target. We could even hold our smartphone up to the sky and



**CELESTRON NEXSTAR 8,
CELESTRON.UK.COM, £1,799**

tap 'GoTo' on a star, and it would move the scope to it - a nice touch. The in-built battery, once charged up, also means you don't need a separate power supply so you can take the telescope anywhere.

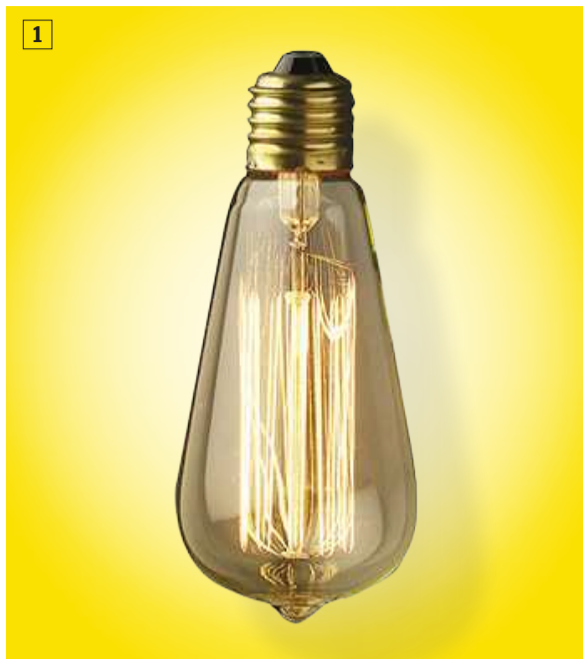
How accurate is it?

The accuracy does depend on how carefully you set the system up and perform the initial alignment. We found that by doing this using the higher magnification 13mm eyepiece, we could get our targets close to the centre of the view. In the wider field of view of the 40mm eyepiece they were usually centred, so you can be certain that what you are looking at really is the object you wanted to see.

Why should I buy it?

For newcomers, the NexStar Evolution 8 might seem expensive at £1,799, but it's loaded with technology that takes the hassle out of setting it up, letting you find objects in the sky quickly. So if you can afford it, it's worth it. It really brings the Universe to your fingertips, so you can amaze your friends with views of planets, the Moon, stars, galaxies and more. ■

PAUL MONEY is an astronomer and reviews editor of *BBC Sky at Night Magazine*



APPLIANCES OF SCIENCE

1 WARM GLOW

LED light bulbs use less electricity, last longer and are safer than the regular variety, but ultimately they're a bit ugly. Not any more. These Edison Light Globes use some clever circuitry to mimic the appearance of vintage light bulbs. They're more expensive than your standard light fitting, but you should recoup some of that cost on your energy bill, plus you'll probably stop buying lampshades too.

Edison Light Globes
From \$15 (£8) plus P&P,
edisonlightglobes.com

2 DIGITAL ROCK STAR

Games like *Guitar Hero* help you feel like a rock star while strumming on guitar-shaped game controllers. The problem is that in the time spent playing a game, you could have taken steps towards becoming a real rock star by learning to play an instrument. gTar fixes this by connecting a smartphone to an actual guitar, and teaches you how to play by lighting up LEDs behind the strings. It'll even help you write and record songs.

gTar
\$399 (£34) plus P&P,
gtar.fm

3 WATCH OUT

Watches that track your activity are usually made out of rubber and covered with neon paint and flashing lights. This means that unless you're a fitness trainer, they're unlikely to match your daily attire. Thankfully, Withings's designers have taken a more sombre approach to watch design. It still tracks all your steps and presents them on a handy app – you can even take it into the pool. But since it looks smarter, you're more likely to wear it.

Withings Activité
\$390 (£292) plus P&P,
withings.com

4 FULLY STACKED

Having to regularly back-up your files is one of the less exciting consequences of modern technology. Thankfully the Ezeecube could take the sting out of protecting all your photos, music and documents. It comes with one terabyte of storage to which you can send data from your phone, computer or tablet. It automatically discards any duplicates, and you can stack another panel of storage on top if you need more.

Ezeecube
\$299 (£175) plus P&P,
www.ezeecube.com

5 BEAR ESSENTIALS

This Bluetooth-compatible, rugged back-up battery charger could save your life, quite literally. As well as letting you charge your smartphone or tablet, the BRV-BANK has an SOS button that flashes a Morse code distress signal in an emergency. There's also a 'bear mode', which triggers an alarm if your phone or charger is moved. It may not scare off a peckish predator, but it certainly will keep sticky fingers off your gadgets.

Braven BRV-BANK
£119.99, braven.eu

6 A SCANNER LIGHTLY

Ever been out at a café, sat reading the paper and thought 'damn, I need to scan this page right this second'? No, us neither, but that doesn't stop us wanting this pocket scanner any less. You simply slide this over the document you want to scan and it'll send the file wirelessly to your PC or tablet. Better yet, it'll let you edit the documents you scan – charts end up on Excel and text opens up in Word.

PocketScan
169 Swiss Francs (£110) plus P&P, dacuda.com



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Galloway

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"I have never been in such a dark place,
quite an experience"

Visit our website to get all the latest information and links. Come and visit us now and see why we are **The UK's 1st Dark Sky Park**

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For more information visit our website
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www.forestry.gov.uk/darkskygalloway

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 **ULTIMATE TEST**

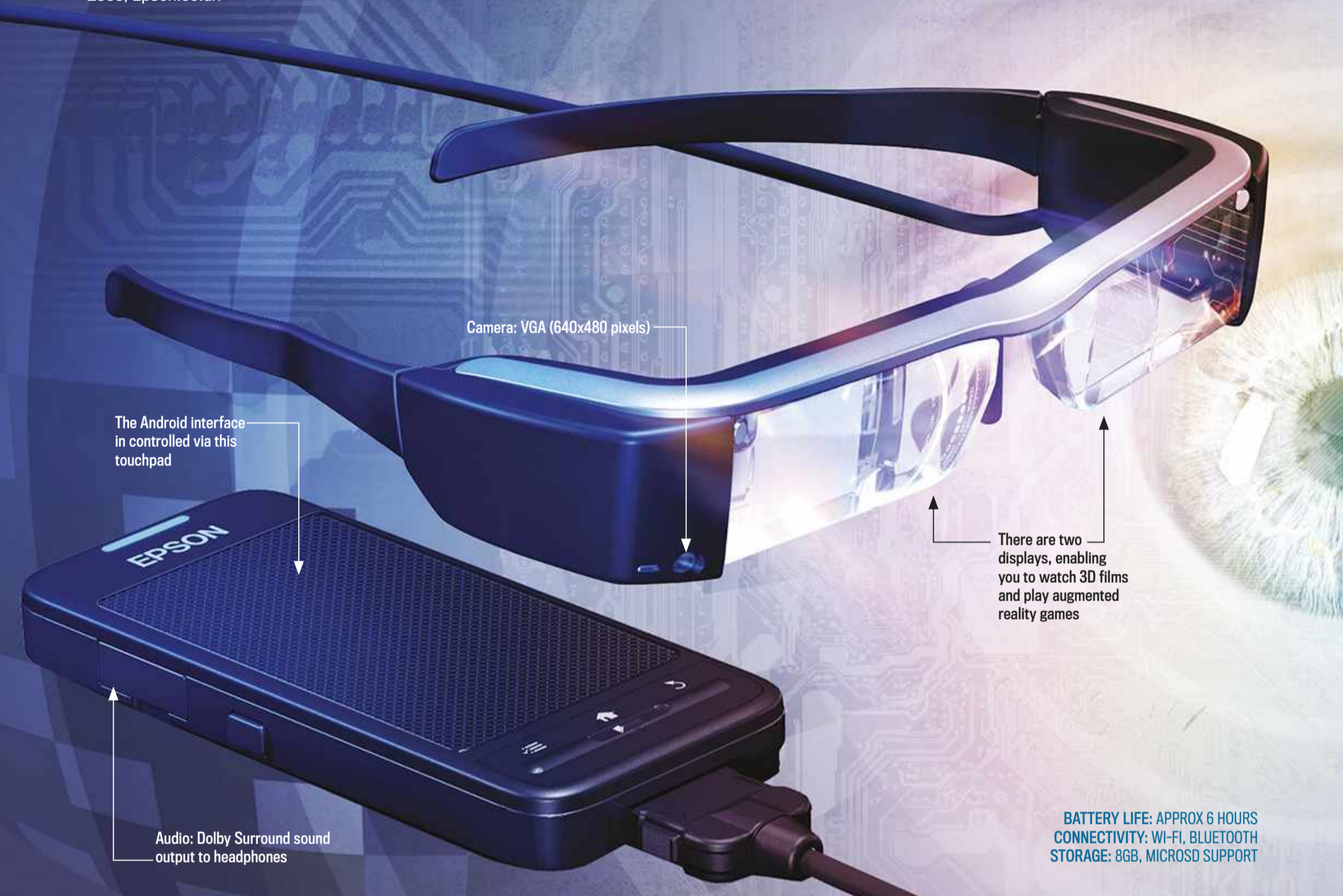
SPECTACULAR SPECTACLES

With Google launching Glass in the UK, **Daniel Bennett** swaps his specs for a smarter pair to try the latest in wearable technology



EPSON MOVERIO BT-200

£569, Epson.co.uk



GOOGLE HAS A habit of changing the world. First its search engine shaped the way we use the internet and then its Android smartphone operating system put the web into more hands than ever before. Now the Californian company wants to shake things up with a new device that will put the internet right in front of our noses: Google Glass.

Google doesn't always get it right though. Remember Google Lively? No, you're not alone. It was a virtual world, akin to *Second Life*, where avatars could roam around digital playgrounds – mostly telling each other how bored they were – while browsing the web. What about

Google Wave? The awkward love child of an email client, instant messenger and document sharing service that no one really asked for. It begs the question: which group will Glass fall into? Is it a well-meaning gadget that no one really needs or is it the next piece of tech we won't be able to live without? Well, if first impressions are anything to go by, then it might be the former.

After spending a number of hours with Glass, I'm struggling to find a reason to justify buying one. The first barrier is the price. Right now, it will cost you £1,000 to be part of Google's 'Explorer' programme – in other words the beta test – and receive a pair of

smartglasses. The next hurdle is the form. Technologically speaking, Glass is a marvel. Google has squeezed in most of the hardware you'd find in a smartphone (and more) into just one arm of the specs. I'm loath to criticise such a feat, but in the end all this tech makes for a cumbersome pair of specs that are about as subtle as a pair of googly eyed glasses.

WALKIE TALKIE

It doesn't help matters that you have to talk to Glass to get it working. My first encounter with Glass at its launch involved trying to get its attention in a room full of people chanting 'OK Glass'.

Obviously this isn't a typical use, but I'm not sure anyone actually likes talking to their gadgets, especially not in public. You can use the touch-sensitive panel on the side of Glass's right arm to navigate through the menus, but it's not the most ergonomic system.

Then there's the screen, which hovers just at the top-right corner of your vision. Although it's clear and easy to read, the intention is to 'keep you in the moment' – so you don't have to keep looking at your phone. However, you still have to look in the corner of your vision to be able to focus on what Glass is telling you.

All of the above makes it sound like I'm not a fan of smartglasses.

GOOGLE GLASS

£1,000, Google.com/glass

BATTERY LIFE: ONE DAY
CONNECTIVITY: WI-FI, BLUETOOTH
STORAGE: 12GB

But that's not the case. Glass manages incredible feats, making it far more exciting than the incremental phone updates we've seen tech companies churn out over the last few years. For example, the Word Lens app adapts signs in foreign languages: it blanks out the text and replaces it with an English translation. Or there's the Star Chart app, which will overlay constellations in the night sky over your view. Then there's the sat-nav that gives you turn-by-turn directions on top of what you see ahead. The trouble is, right now, I can do all of these things well enough on the device that's already in my pocket. But there could be another way...

Before Glass was little more than a rumour, a number of companies released their take on smartglasses. In fact, Epson is now already on its second iteration: the Moverio BT-200. It's half the price of Glass (£569) and for that you get twice the number of displays. The Moverio's arms are loaded with tiny projectors that throw out images onto two transparent lenses. This means you can see a lot more information and you don't have to shift your focus to see the displays. The bigger display size means apps can be more adventurous. We tested out one scenario in which we looked at QR codes (square barcodes). These were placed at

key points in an ancient temple and sparked Moverio to overlay a 3D animation of what the site would have looked like hundreds of years ago. We were also able to watch films and play augmented reality games.

SPECS APPEAL?

The Moverio isn't without its own faults, though. At this stage they are hopelessly heavy. They're also umbilically attached to a touchpad unit where its brains are stored – you're not going to see someone walking down the street with a pair. And although it runs Android, it doesn't have the app support that Glass will have.

Ultimately, neither really demonstrate whether smartglasses are likely to have mass appeal and neither tempted me to get out my wallet. Nevertheless, smartglasses are still one of the most exciting prospects in the tech world today. There are already some incredible applications. The Moverio has been adapted to help the partially blind regain a degree of sight and Glass is being modified to present surgeons with patients' vital stats during surgery. Whether or not they are the 'next big thing' is yet to be seen, but one thing is clear: smartglasses will change lives. ■

DAN BENNETT is the reviews editor of *BBC Focus Magazine*

Become a smartphone stargazer

It hasn't always been easy to get started in stargazing. The expensive kit, the hours poring over instruction manuals, the indecipherable star charts. Many people with an interest in astronomy may have been put off by the enormous amount of time it appears to take to master the hobby. But all this is now a thing of the past with the arrival of Celestron's revolutionary telescope, the NexStar Evolution. This simple to use scope, mount and tripod combo has been designed for the tech savvy. The world's first telescope with built-in WiFi, the NexStar Evolution can be controlled via a free, dedicated app from your smartphone or tablet. It's easy. Just point your device skyward, give it a quick alignment and choose a celestial sight to discover. Not only will Celestron's fact-filled app reveal more about the object, but with a

The world's first telescope with built-in WiFi, the NexStar Evolution can be controlled via a free, dedicated app from your smartphone or tablet

single click, it will slew the telescope across the night sky, perfectly aligning your eyepiece with the distant celestial gem you've chosen to observe. The built-in planetarium will show you exactly what can be seen in the sky directly above you and in real-time, with over 120,000 objects in the app's database.



Perfect for beginners, the NexStar Evolution comes in just two parts. With the telescope tube already attached to the mount it's just a case of securing it to the tripod, powering up the app and off you go! But this ease of use doesn't equate to a loss in quality. The NexStar Evolution 6, the smallest scope in the series which also includes 8 and 9.5-inch models, is comprised of a compact, 6-inch Schmidt-Cassegrain optical tube housed in a high-performance, computerised GoTo mount. The NexStar Evolution's built-in, rechargeable - and replaceable - lithium-ion battery will provide enough power for 10 hours of observing and, with thousands of celestial targets to discover already programmed into the app, you'll need it. There's even a USB port to charge your tablet or smartphone during a stargazing session.

With no need to purchase a separate mount or tripod, the NexStar Evolution is an easy and affordable way to discover more about the wonders of the Universe. This sturdy telescope package has been built with simplicity and durability in mind. The solid, industrial design reflects the NexStar Evolution's reliability. There's no need to fiddle around with unfamiliar bolts and screws. All you need to do is turn on, log in and observe as the NexStar Evolution reveals to you the beauty of the cosmos in stunning detail.

The Celestron Evolution series is distributed in the UK by David Hinds Limited.

Tel: 01525 852696

Email: astro@dhinds.co.uk

To find your nearest dealer please visit www.celestron.uk.com.



► With built-in WiFi, the NexStar Evolution can be controlled remotely. But a hand controller is included for traditionalists.

A new way to observe

Suitable for both Android and iOS, Celestron's SkyPortal app will simulate the night sky from any point on Earth 100 years into the past and future. It will give you a real-time assessment of the sky above you including star names, constellations, planets, nebulae and galaxies - when you find an object you like, tap the app and your scope will slew to it! With over four hours of audio commentary, the SkyPortal app takes you on a comprehensive tour of the Universe and allows you to learn more about the history and science of the cosmos with hundreds of written descriptions. Not only does Celestron's revolutionary app offer a simple way to navigate the night sky, it teaches you along the way.



THE SHAPE OF THE MILKY WAY

BY STUART CLARK

Ever since Galileo first spotted individual stars in the mist of light that stretches along the night sky, astronomers have been endeavouring to describe our Galaxy and our place within it

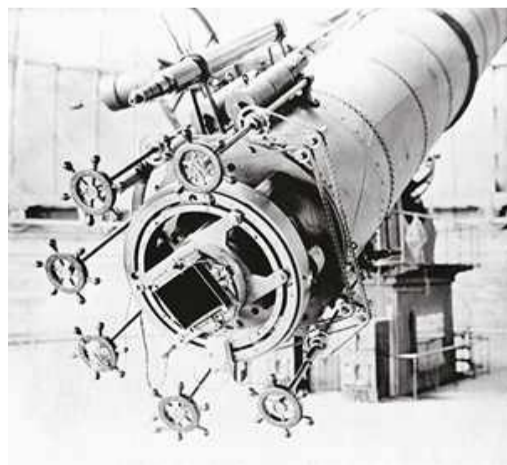
ON A DARK, cloudless night, it is hard not to notice the Milky Way. At most times of the year, it stretches across the sky in a limpid band of light that invites speculation about its nature. To the Hindus it was the great sky river, the celestial equivalent of the Ganges. To the Maori, it was the canoe of a lost traveller who scattered bright stones in the stream (the stars) so others would not suffer his fate. To the Greeks and the Romans it was the spilt milk of a goddess, either Hera or Opis.

Beyond such flights of fancy, the story really starts in 1610, when Galileo raised his telescope to look at the luminous band of light. With no streetlights to hide it from view, it would have been a natural target for observation back in those days. Galileo's telescope had only a tiny field of view but it was enough to see that the light of the Milky Way resolved into a plethora of individual stars.

This should not have come as a complete shock. Way back in Ancient Greece the philosophers Anaxagoras and Democritus had both speculated that the Milky Way might be a

collection of distant stars. Islamic astronomers also proposed this but it was Galileo's observations that gave us the first proof. His records mark the beginning of the scientific study of the Milky Way, and the wider Universe.

At the time the observations raised a profound theological question about why God had made the human senses incapable of seeing all of Creation. Answering this became a driver behind the early investigation of nature. Through the invention of telescopes and microscopes that could extend the range of human senses, mankind could better understand God's handiwork.



This 40-inch telescope at the Yerkes Observatory, Wisconsin, helped William Morgan discern our Galaxy's spiral arms

As science progressed, it became less about the glorification of God and simply about collecting knowledge. One thing was abundantly clear about the Milky Way from the very beginning: the stars were not distributed randomly around the sky. The band of light suggested that most were concentrated into a disc.

This thinking guided philosopher Immanuel Kant in 1755 to make an extraordinary deduction. Based upon Newton's law of gravity, which described the action of the force, and the observation that the planets of the Solar System described a band around the Sun, he suggested that the Milky Way was a vast rotating collection of stars all held together by gravity. A natural question was then to ask the location of the Sun and planets within this rotating system.

This was where the Herschels came in. William Herschel lived with his sister, Caroline, and together their hobby was astronomy. His life changed completely on 13 March 1781 when he discovered the seventh planet Uranus. In 1785, he began a series of star counts. He assumed that stars were more or less evenly distributed throughout the disc of the Milky Way, and



The core of our Galaxy is seen as a dense mist of stars, the Milky Way, in the constellation of Sagittarius

> IN A NUTSHELL

How do you study the shape and size of something when you're inside it? It was a conundrum faced by astronomers over hundreds of years as they sought to understand our place in the Galaxy and the wider Universe.

**BBC
TWO**

If you enjoy this article, don't miss *How We Got To Now*, a 5-part series featuring author Steven Johnson, on BBC Two in October.

➔ that by counting them in all directions he could work out where we are in relation to the centre.

It was not terribly successful because no one then knew that the Milky Way is full of dust, which absorbs the light from more distant stars, rendering them invisible. This made it seem as if there were more or less the same number of stars in every direction and so Herschel concluded that the Milky Way must be like a 'grindstone'; a flat disc of stars more or less centred on the Sun.

Although wrong, this was effectively the state of the art even into the 20th Century, when Dutch astronomer

Jacobus Kapteyn tried the same method with contemporary telescopes. He devoted time to this project on and off for his whole life, finally publishing his masterwork in 1922 under the name: *First Attempt At A Theory Of The Arrangement And Motion Of The Sidereal System*. He concluded that the Milky Way was about 40,000 light-years across, but the dust problem led him to place us very close to the centre of the Galaxy.

In fact, by this time, the correct location of our Solar System had been computed by Harlow Shapley, an astronomer from Nashville, Missouri who went on to become the Director

of Harvard Observatory, Massachusetts. The year was 1920 and instead of stars, he counted globular clusters. These are spherical collections of stars that can be seen all over the sky. Shapley reasoned that they would be in orbit around the centre of the Galaxy, and that if the Solar System were in the centre of the Milky Way, the globular clusters would be dotted evenly around us too.

Instead, he found that most were located in the southern sky, around the constellation of Sagittarius, where the Milky Way made a distinctive bulge in the sky. Shapley concluded that this was the direction of the Galactic

THE KEY DISCOVERY

A moment of genius enabled the American astronomer William Morgan to devise a relatively simple way to find out if the Galaxy had spiral arms: mapping the bright stars

AT THE BEGINNING of the 20th century, the dominant view of the shape of the Milky Way was the grindstone model. This was named by William Herschel, who concluded that the Galaxy was a flat, solid disc of stars. Chicago astronomer William Morgan changed this view in a single night as an Archimedean inspiration struck him while walking from the Yerkes Observatory, where he worked, back to his home.

He had been studying the brightest stars for many years and suddenly realised that their distribution across the night sky was not random. Instead, they described spiral patterns around the centre of the Galaxy. He marshalled his observations and presented his evidence in a 15-minute talk to the American Astronomical Society on Boxing Day, 1951.

He was so convincing that he received a rapturous ovation for the work. Tragically, he

never really had the chance to follow it up. Haunted by the memory of a physically abusive father, he suffered a nervous breakdown shortly afterwards.

By the time he returned to work several years later, his breakthrough had been overtaken by Jan Oort using radio telescopes. Nevertheless, Morgan was the first astronomer to show that the Milky Way has a spiral shape rather than a plain disc.



William Morgan's work described a galaxy with three spiral arms: the Perseus, Orion and Sagittarius arms

centre, and set about calculating the distances of the globular clusters using the brightness of pulsating variable stars as his yardstick.

He concluded that the Sun is located about three-fifths of the way from the centre of the Galaxy to its edge. This is indeed the location of the Sun but Shapley significantly overestimated the absolute distances because, like those who came before him, he did not understand that there was obscuring dust in the Milky Way. He mistook the dimming effects of the dust as being due to distance, and so arrived at a figure for the Sun's distance from the centre of the Galaxy as 90,000 light-years. We now know that the correct distance is about 27,000 light-years.

SPIRALS IN SPACE

The next piece of evidence to slot into place about the shape of the Milky Way was its spiral structure. By the time Shapley was at work, evidence was mounting that the disc may be shot through with a spiral pattern of stars.

Back in the middle of the 19th Century, William Parsons, the 3rd Earl of Rosse had built the Leviathan telescope. This gigantic telescope was 1.8m across and higher than a house. It was constructed at Birr Castle, County Offaly, Ireland. Using it, Rosse could see spiral structures in some of the nebulae scattered across the sky. Could the same be true for the Milky Way?

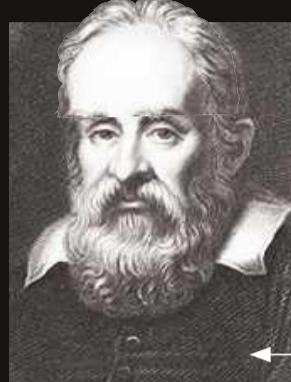
By Shapley's time, there was a debate among astronomers about whether the spiral nebulae were distant galaxies or nearby gas clouds. This was resolved in 1925 when American astronomer Edwin Hubble identified variable stars in some of the spiral nebulae and calculated their distances. This showed that they were much further than the confines of the Milky Way that Shapley had worked out. The spiral nebulae had to be distant galaxies, full of their own collections of stars.

Thus, astronomers began to strongly suspect that the Milky Way too must be a spiral. But how could this be proven? It was completely impossible for astronomers to magically launch themselves out of the plane of the Galaxy to look down on it from above – the distances were simply too great.

Dutch astronomers, inspired by their great doyen Kapteyn,

CAST OF CHARACTERS

Galileo started our quest to understand the Galaxy, before other great minds took up the challenge



Galileo Galilei

(1564-1642) was an Italian astronomer and physicist who was the first to publicly record his observations of the night sky through a telescope. He achieved infamy when the Roman Catholic Inquisition convicted him on a charge of being 'vehemently suspected of heresy'. He spent the rest of his life under house arrest.



William Herschel

(1738-1822) was a musician and astronomer who lived with his sister Caroline in Bath. William's discovery of Uranus brought him fame and a stipend from the King. He and Caroline moved to Slough, so that he was within calling distance of Windsor, for when King George III wanted to drop round with guests to look through the telescopes.



Jacobus Kapteyn

(1851-1922) was a Dutch astronomer who spent the majority of his career at the University of Groningen in the Netherlands. His study of stellar motion was the first step to proving Immanuel Kant's deduction that the Galaxy was a rotating system of stars. After retiring at 70, he was persuaded back to work to help upgrade Leiden Observatory.



Harlow Shapley

(1885-1972) was an American astronomer, whose first ambition had been to become a journalist. When that course was not available at his local university, he applied for the first subject in the prospectus that he could pronounce: astronomy (rejecting archaeology on the grounds of articulation). In his spare time, he was fascinated by ants.



Jan Oort

(1900-1992) was a Dutch astronomer who pioneered the use of radio telescopes using a German radar abandoned after World War II. He made many discoveries throughout his career, but is mostly remembered for the hypothesis that comets come from a cloud surrounding the Solar System. This is now called the Oort cloud.

TIMELINE

It's taken centuries of stargazing to arrive at our current understanding of the structure of the Milky Way



Galileo Galilei raises his telescope to the sky and discovers that the band of light known as the Milky Way is actually a vast collection of individual stars.

1610

1755

Immanuel Kant suggests that the Milky Way is a rotating system of stars all held together by gravity. This is only proved beyond doubt in 1927 by Jan Oort.



William Herschel and his sister Caroline begin to count the number of stars in particular directions across the night sky, hoping this will betray the shape of the Milky Way.

1785

1920

Harlow Shapley studies the distribution of globular star clusters across the night sky and finds them clustering in the south. This shows that the Sun is located far from the galactic centre.



1927

1951



Jan Oort continues the work of his supervisor, Jacobus Kapteyn, in studying the motion of stars. He shows that they follow a systematic pattern, proving that the Milky Way is rotating.

William Morgan presents a study of the brightest stars in the Milky Way, showing that their distribution across the night sky is strong evidence for our Galaxy having spiral arms.



tried again to count stars. They reasoned that if there was a spiral structure to the Galaxy, then the density of the stars in the vicinity of a spiral arm would increase. They counted and they counted, and they got nowhere. Indeed, one of this method's practitioners became so disillusioned that he claimed in the 1930s that the problem of the Milky Way's structure would likely remain unsolved during his lifetime.

Astronomers needed a different way to attack the problem. In America, William Morgan focused on just the brightest stars. These are the blue supergiant stars and they are much less numerous than the run-of-the-mill yellow and red stars. He traced them out across the sky, showing that the pattern suggested three spiral arms. He called these the Perseus, Orion and Sagittarius arms. Before he could capitalise upon his discovery, however, ill health led to him being hospitalised and astronomer Jan Oort from the University of Leiden, the Netherlands, stole a march using radio telescopes.

GALACTIC RADIO

Unlike visible light, radio waves aren't troubled by the interstellar dust and so can be seen across large tracts of the Galaxy. Radio telescopes can be tuned to isolate single frequencies and so pinpoint the radio waves coming from specific molecules or atoms. In particular, Oort and colleagues targeted the 21cm waves that are spontaneously emitted by hydrogen atoms.

They mapped out giant clouds of gas across the Galaxy that also appeared to show a spiral shape. Whereas Morgan could only see the nearby structure, Oort and colleagues could see across most of the Galaxy. They interpreted their data to mean that four arms of stars wrapped themselves around the Milky Way. These arms were termed Norma, Scutum-Centaurus, Perseus and Sagittarius. In this view of things, Morgan's Orion arm is just a spur that runs from the Perseus to the Sagittarius arm, rather than a complete arm in its own right.

In recent years, however, the four-arm model has been challenged. Some astronomers believe that there are just two major arms, and that the rest is composed of spurs and arcs of stars. Spiral galaxies composed of many bits of arms are known as

NEED TO KNOW

Wrap your head around the Milky Way with these key terms

1 GALAXY

A galaxy is a collection of many millions or billions of stars. The nature of galaxies was recognised by Edwin Hubble in the 1920s. He classified them according to their shape, showing that many of them are spirals.

2 THE MILKY WAY

Traditionally this is the name for the misty band of light that stretches across the night sky. This is now known to be the plane of our Galaxy, and the name is used to describe our Galaxy and its 200 billion stars.

3 NEBULAE

From the Latin word for cloud, nebulae is the term used for clouds of dust and gas in space. Originally used for galaxies too, this usage became increasingly anachronistic after Hubble showed galaxies to be distant collections of stars.

This is the collective name for the Sun and its family of planets and their moons. The Sun contains more than 99 per cent of the mass of the Solar System. Its gravity pulls the planets into orbit.

‘flocculent spirals’, whereas those with a few, well-defined arms are termed ‘grand design’.

The European Space Agency’s star-mapping Gaia spacecraft will add data to this debate. Launched in December 2013, it is conducting a survey of one billion stars in the Milky Way. It will record precise positions, distances and movements of these stars, which will give more details about how the Milky Way is structured.

Radio telescopes on Earth are also being used in another way to tackle this problem. They are targeting specific gas clouds across the Galaxy that happen to emit microwaves in the same way that a laser works. These naturally occurring microwave lasers are known as MASERS and their



ESA's Gaia spacecraft is launched from French Guiana late last year to map the position and motion of a billion stars in the Milky Way to make a three-dimensional map of our Galaxy

distances can be measured with great accuracy. Following their motion over a period of time reveals the movement of our Solar System and so allows the distances to the spiral arms to be calculated more accurately. This refinement will allow the structure to be seen more easily.

While questions remain about the number of spiral arms, one thing now does seem clear. The centre of the Galaxy is a bulge of older stars, located in the direction of the constellation of Sagittarius. The central bulge is elongated into a bar of stars some 3,000-16,000 light-years in length, from which the spiral arms (however many of them there really are) begin.

The centre of the Galaxy is home to a supermassive black hole containing approximately four million times the mass of the Sun. This has grown during the 10-billion-year history of our Galaxy, and continues to grow today. Astronomers are tracking a gas cloud, known as G2, that could be eaten by the black hole this year. Even if it were to be swallowed completely, the black hole will hardly recognise it as a snack. G2 ‘only’ contains about three times the mass of the Earth.

The latest twist took place in 2010, when two gigantic bubbles of particles were discovered by NASA’s Fermi Space Telescope because of the gamma-rays they were emitting. One is above the centre of the Galaxy, the other is below. They may be driven by star formation taking place around the Galaxy but no one knows for certain.

The Milky Way continues to be a fascinating, mysterious place. Although we know a lot more about its shape than we once did, the details continue to elude us. Meanwhile new features continue to pop up and take us by surprise. ■

Dr Stuart Clark is a Visiting Fellow of the University of Hertfordshire. His latest book is *The Day Without Yesterday*

Find out more

BBC
RADIO
4

Listen to ‘The Milky Way’, an episode of *Cosmic Quest* telling the story of how we discovered our place in the Galaxy, narrated by Heather Couper. <http://bbc.in/ODDmbY>

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TO DO LIST

PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE



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LISTEN



TOUCH



VISIT



READ

PICK OF THE MONTH



The odd-looking shoebill stars in *Tweet Of The Day* and would make a good alarm clock: it clatters its giant bill to make a noise



Tweet Of The Day

→ BIRDSONG IS ARGUABLY the most ubiquitous sound on the planet. From the city to the countryside; the wildest woods to the highest mountains, we're never too far away from a winged warbler. For many of us, though, birdsong has become one of life's background sounds – a distant twittering that's lost amid the perpetual cacophony of rumbling traffic and bleeping gadgets.

Radio 4's *Tweet Of The Day* hopes to rectify that. For 90 seconds every weekday morning at 5:58am, you can listen to a short clip of birdsong, followed by a snippet of information about the crooning critter. The first series, which won radio programme of the year at the Broadcasting Press Guild's 2014 Awards, featured over 250 British birds.

This September, *Tweet Of The Day* goes global with a new series about birds from around the world. Sir David Attenborough will launch the show with Papua New Guinea's blue bird-of-paradise, while other presenters on board include Chris Packham, Liz Bonnin, Miranda Krestovnikoff and Michael Palin.

So what can we expect this time round? "One of the most impressive singers is the superb lyrebird,"

says Brett Westwood, BBC wildlife presenter and *Tweet Of The Day* scriptwriter. "This Australian bird has the remarkable ability to imitate the calls of other birds, and it's even been recorded imitating chainsaws, camera shutters and workmen talking. It seems to be able to do anything."

Then there's the emperor penguin, which sounds a bit like a donkey on heat. "Emperor penguins breed in the Antarctic winter, when temperatures can drop to -50°C," says Westwood. "The males incubate the eggs while the females go off on fishing excursions. Each penguin makes a distinct braying sound, which helps their partner to find them within this dense colony of hundreds, even thousands, of penguins."

So why not start your day with a burst of birdsong? And don't worry if you can't get up at 6am, as you can listen to every episode online.

JAMES LLOYD

BBC
RADIO
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Tweet Of The Day starts on
BBC Radio 4 on 1 September
<http://bbc.in/1a7926r>

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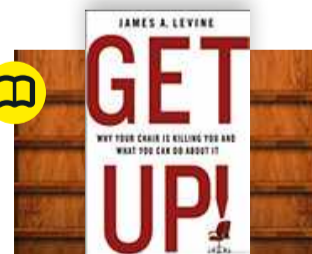
Guy Martin's Spitfire

The speed fiend takes to the skies, resurrecting the aviation icon. **p102**



Making The City Playable

Designers imagine future cities, which seek to make urban spaces more like playgrounds. **p105**



Get Up!

In his new book, James Levine argues that we should all get up off our behinds in an effort to improve health. **p106**



WATCH

TV, DVD, BLU-RAY & ONLINE

WITH TIMANDRA HARKNESS

28 AUGUST

Ultimate Swarm

Eden, 9pm



George loves insects so much he wears them

STRENGTH IN NUMBERS is not the only benefit of being part of a swarm: there's also safety, warmth and even more intelligence. Fearless wildlife experts Steve Backshall and George McGavin (pictured) travel to America, get covered in bees and get to know some fire ants. On the way they reveal the science of swarms - migration, population, and the impressive hive mind of shared information.

SEPTEMBER

Taming Nature's Giants

Channel 4, September TBC



SOME ANIMALS SEE us as prey and vet Mark Evans wants to find solutions to protect people without harming wildlife. So he meets experts training Namibia's crocs with electric shocks, and tests shark deterrents in Australia. In Canada, he scares polar bears away from a town with long-range acoustic technology. Can he take us off the menu without removing the animals themselves?

SEPTEMBER

Web Junkies

BBC Four, September TBC



IT ENFORCES A strict regime of therapy and military drills on its young inmates. For 10 years, this treatment centre near Beijing has received young men diagnosed with addiction to the net. Premiered at the Sundance Film Festival, this documentary asks if addiction is a useful way to describe spending too much time online, and whether we can learn from the strict regime of the Daxing centre.

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze



EDITOR'S CHOICE

A marvel of British engineering... and a Spitfire

SEPTEMBER

Guy Martin's Spitfire

Channel 4, September TBC

IN MAY 1940 Spitfire N3200 took off from RAF Duxford to cover the retreat from Dunkirk. Shot down over northern France, it sank into a sandy beach. The pilot, Squadron Leader Geoffrey Stephenson, escaped to Belgium, but was imprisoned in Colditz. Decades later, the wreckage was discovered, and finally found its way back to Duxford, now an air museum. There, a specialist restoration company took on the challenge of making it airworthy again.

Lorry mechanic, motorcycle racer and drily engaging presenter Guy Martin joined the team for this two-year

project. Not only do they use the original Mark 1 Spitfire blueprints to put each damaged, corroded or lost component back in working order, but they bring to life the history of the iconic aeroplane.

Squadron Leader Stephenson, who went on to be the Queen's Pilot, has a remarkable story, revealed for the first time through his diaries. But behind the pilots were thousands of unnamed workers who built the aircraft, and mechanics who maintained and repaired them.

When the work is complete, Guy invites Stephenson's daughters to Duxford to watch it fly again.

FROM 3 SEPTEMBER

Brain Games

National Geographic, 8pm



HOST JASON SILVA is back with new episodes of the entertaining brain science series. Not seen it before? Take a chance on the first instalment, about our approach to taking risks. How good are we at weighing up the odds? Find out with experiments, and input from neuroscientists. The second part is on addiction, so don't blame us if you end up hooked on this series.

9 SEPTEMBER

Formula E

National Geographic, 5pm



FORMULA 1 NOW has a fossil fuel-free rival. Formula E is a new, electricity-powered race series. This documentary follows British engineers and designers with some major challenges to overcome. They have to battle the technical limitations of electric car technology, weighing safety against efficiency, battery life against raw power.

FROM 11 SEPTEMBER

Wild Ones

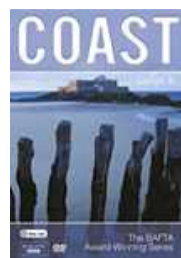
Eden, 6pm

Did the gazelle make it? You'll have to watch *Wild Ones* to find out



➔ EVOLUTION MAY BE about the survival of the fittest, but to fuel our best pub arguments we need to know more. Which animal is the fastest, the biggest, the deadliest or the cutest? This 13-part series uses such apparently simple questions to examine different aspects of animal behaviour. From hunting prey to hiding from predators, from courtship rituals to feeding your offspring, nature throws up a surprising range of solutions to the everyday problems of survival.

DVD & BLU-RAY



Coast Series 9

BBC, £17.49

IN THE MOST recent series, discover why Greenwich became the centre of world navigation, what links France with Ordnance Survey maps, and why the Scots went to Nova Scotia.



Futurescape With James Woods

Discovery, £10.25

THIS SERIES, HOSTED by the popular actor, explores futuristic scenarios with the help of scientist Michio Kaku. Each episode takes one scientific advance and asks where it might take us.

ONLINE

BBC

Eric Idle Performs Theme For The Infinite Monkey Cage

www.bbc.co.uk/programmes/p021x88c



LISTENING TO RADIO 4 will never be the same after you've seen the puppet versions of Robin Ince, Professor Brian Cox and *Monty Python* star Eric Idle, plus a finite number of monkeys.

YOUTUBE

Singing Wine Glasses

<http://youtu.be/FNTmzX3GpOU>



IN THIS FILM from the Royal Institution's 'Science With Children' ExpeRimental series, Manchester Science Festival Director, Dr Marieke Navin, makes music with glasses of wine. Er... squash. Definitely squash.

YOUTUBE

The Science Of Ageing By Professor Linda Partridge

<http://youtu.be/SS5SpGPo0fE>



THERE'S CHEERING NEWS in this Academy of Medical Sciences film - we don't just "wear out like washing machines". Gain an insight into the work of scientists tackling ageing at the labs of the University of Cambridge.



LISTEN

BBC RADIO PROGRAMMES
WITH TIMANDRA HARKNESS

3 SEPTEMBER

The Life Sub-Aquatic

BBC Radio 4, 11am,

MARINE BIOLOGIST DR Helen Scales celebrates 50 years of human life beneath the waves. She speaks to Fabien Cousteau, who has broken grandfather Jacques's record for time spent underwater, discovers Sylvia Earle, the first female aquanaut, and visits an ocean floor research station.

8 SEPTEMBER

Mother Of The Sea

BBC Radio 4, 11am

WONDERING WHAT FORMER *Material World* presenter Quentin Cooper is up to these days? He's visiting a shrine in Japan at which fishermen honour not a goddess, but an English algae expert who helped turn a traditional crop into a global industry.



Quentin Cooper witnesses the Japanese worship of an English algae expert

9 SEPTEMBER

What's In Our Water?

BBC Radio 4, 9pm

MOST OF THE water we drink is recycled from other people's urine. Chemistry Professor Andrea Sella asks if we should be worried about imbibing traces of the drugs they may have taken. Fearlessly, he even does some chemical analysis at a music festival.



Mmmm good 'ol H₂O, with a little extra...

9 SEPTEMBER

Patients Doing It For Themselves

BBC Radio 4, 9pm

MEDICINE HAS A dilemma: ethical regulation, designed to protect patients, can keep them waiting for new drugs they'd willingly test on themselves. Vivienne Parry investigates the groups taking research into their own hands.

PODCAST

Discovery

www.bbc.co.uk/podcasts/series/discovery



DOWNLOAD THESE SCIENCE documentaries from the BBC World Service. From Jack Stewart on driverless cars to Dr Tiffany Jenkins finding out what the brain can tell us about beauty, these in-depth examinations of hot topics in science are added weekly.



TOUCH

SMARTPHONE & TABLET APPS
WITH KATE RUSSELL

ISS Detector

Android, ISS Detector, free



SPACE IS A lonely place, so why not give the astronauts aboard the International Space Station a wave next time they go whizzing overhead with the help of ISS Detector? The app reveals when the

ISS will pass over your location, complete with weather reports, direction and altitude so you have the best chance of spotting it with the naked eye – it looks like a star moving across the sky at a constant rate. It also lists good times to view flares from passing Iridium satellites, which is when sunlight is reflected directly down at Earth, lighting the sky with a bright flash for a few seconds.

NASA Science: A Journey Of Discovery

iPad, NASA, free



WE HUMANS LOVE to talk about the weather, but what effect does the weather from space have on us? Find the answer to this, and other big questions like 'was there ever life on Mars?' with the help of NASA's excellent free iPad app.

The app is updated regularly with all the latest information from NASA's science missions, revealing everything the famous space agency learns about planet Earth to the farthest edges of the Universe. And it's all wrapped up in beautiful high-definition interactive visuals.

mySoil

iOS/Android, British Geological Survey, free



BACK DOWN ON Earth, gardeners and geologists alike will enjoy the free mySoil app from the British Geological Survey and the Centre for Ecology and Hydrology. This app will help you understand more about what's under your feet using GPS location-based services coupled with a detailed European

map of soil properties. Fire it up and it tells you things like soil type, depth, organic matter, texture and pH balance. The green-fingered among you can then use this information to determine which plants will give you the best possible results for the soil in your garden.

KATE RUSSELL is a technology journalist and BBC *Click* presenter



VISIT

EVENTS & EXHIBITIONS
WITH JHENI OSMAN



3 JUNE - 7 SEPTEMBER

Dino Jaws

New Dock Hall, Leeds, £5.95, <http://dinosaursinleeds.co.uk>

Reptiles: cold-blooded. Mammals and birds: warm-blooded. So what are dinosaurs? Discover more about the pre-historic creatures at this exhibition, complete with animatronic beasts.

4-10 SEPTEMBER

Orkney Science Festival

Orkney, <http://oisf.org>

Discover the latest developments in wave and tidal power, the maths of knitting and the physics of hula hoops at the week-long festival.



6-11 SEPTEMBER

British Science Festival

Birmingham, www.britishtscienceassociation.org

This year the festival heads to Birmingham. With famous faces like Alice Roberts (pictured) and rock-star physicist Brian Cox, family shows and hands-on experiments, it's not one to miss.

11 SEPTEMBER

Gas! GAS! Quick, boys!

Pfizer Lecture Theatre, Cambridge, 7-8pm, free, <http://bit.ly/Uxlm9h>

The Great War could have been called The Chemists' War. Chemistry killed, but it also protected troops, healing the sick and wounded. This talk by Michael Freemantle looks at how chemicals shaped the conflict.



FROM 13 SEPTEMBER

Space: A Beginner's Guide

Centre for Life, Newcastle, free with admission, life.org.uk

Find out the sticky end you'd come to if you fell into a black hole and explore the galaxies, planets and comets at this new exhibition.

16 SEPTEMBER

The Reverend Austen's Sundial

Herschel Museum, Bath, 10.30-11.30am, £12, <http://herschelmuseum.org.uk>

On an out-of-this-world private tour, get up close and personal with all sorts of intriguing astronomical instruments in the museum.



Could cities' waterways become the highways of the future?

EDITOR'S CHOICE

10-11 SEPTEMBER

Making The City Playable

Watershed, Bristol, £125, £60 concessions, ideasfestival.co.uk



FROM PIANO STAIRS to traffic mimes, what are our cities going to look like in the future? Urban planners, tech giants, small companies, artists and designers download their visions at this two-day international conference, which explores the city as a playground. This 'playable city' is a step on from the current trend for the 'smart city'. Technology is still key, but the city is also focused on people and their needs. Sounds like e-topia in the making.



21 SEPTEMBER

The Wheels And Wings Show

National Museum of Flight, East Lothian, 10am-5pm, £11/£6, nms.ac.uk

Join talks by engineers and transport experts, see classic cars, watch gravity-defying stunts – and have a go on a Segway.

23 SEPTEMBER

The Hockey Stick And The Climate Wars

Victoria Rooms, Queen's Rd, Bristol, 6-7:15pm, free, ideasfestival.co.uk

Michael E Mann is one of the brains behind the controversial 'Hockey Stick' graph, which depicts changes in Earth's temperature back to 1000AD. Book a place and hear him explain how the graph sparked an uneasy relationship between science and politics.

25 SEPTEMBER

Longitude: Back And Forth Across The Years

National Maritime Museum, 6:30-7:30pm, £5, royalsociety.org

The 2014 Longitude Prize seeks solutions to six big issues – from beating dementia to carbon-free flight. Join Astronomer Royal Martin Rees as he discusses the future of scientific innovation.



READ

THE LATEST SCIENCE BOOKS REVIEWED

H Hardback **P** Paperback

Get Up!

Why Your Chair Is Killing You And What You Can Do About It

James A Levine

Palgrave Macmillan **P** £10.99

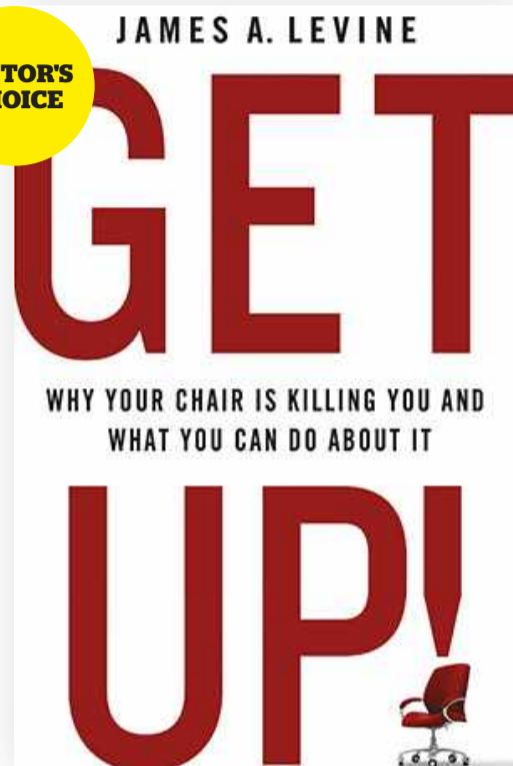
I MET THE hyperactive Dr Jim Levine when I was making a film for BBC *Horizon* called 'The Truth About Exercise'. He came bouncing up to me in the café where we were filming clutching an indecent set of underwear, which he called Fidget Pants. Sewn into these pants were accelerometers, designed to measure how much movement you do in a day. The answer, in my case, was not enough.

Jim, inventor of the stand-up treadmill desk as well as numerous devices for tracking activity, is a man who is absolutely passionate about getting one simple message across: the chair is a killer. These days, thanks in part to the television and the computer, we sit, on average, for 13 hours a day. Going to the gym does not compensate for what happens the rest of the time.

Get Up! neatly summarises many decades of research, weaving Jim's personal story in with the science. It starts with 11-year-old Jim meeting his first true love, Joanne. Joanne is a snail, and the young Jim spends many hours studying and measuring her movements. A child who has his head shoved down the toilet as a punishment for being fat, Jim also experiences the curse of being

"He's a man who is absolutely passionate about getting one simple message across: the chair is a killer"

EDITOR'S CHOICE



overweight. Not surprisingly, these two obsessions come together in later life when he discovers the joys of NEAT – 'Non-Exercise Activity Thermogenesis'.

We need calories to digest food and keep our bodies going. These processes account for over half of all the calories that a sedentary person burns in a day. Beyond that there is NEAT. This, as its name implies, refers to the calories you burn when you are active but not actually doing exercise. It could be doing housework, taking the stairs, walking to work, or even just standing.

Jim's studies have shown that an active person with a high NEAT level can burn up to 2,000 calories a day more than a less active person of the same size. Low NEAT, he argues convincingly, is linked to all manner of conditions: weight gain, diabetes, heart disease and cancer. So how do you boost your NEAT? That is really what this book is about.

Jim persuaded me, while making the *Horizon* film, to spend less time sitting down. I'd be disappointed if this book doesn't have the same effect on you. You never know, it could save your life.

■■■■■

MICHAEL MOSLEY is a writer, doctor and BBC science presenter

MEET THE AUTHOR



James A Levine

In what ways is sitting damaging?

The recent National Institutes of Health review identified 34 chronic diseases and conditions that are associated with excess sitting. Not only is long-term sitting associated with poor posture, back pain, neck pain, carpal tunnel syndrome, swollen ankles and aching feet, but it has also been linked to obesity, type 2 diabetes, high blood pressure, cardiovascular disease and several types of cancer, the most prominent of which is breast cancer. There are about 10,000 publications in the medical literature about this issue, and it's clear that sitting has a profound influence on our bodies.

So what can we do about it?

There's an amazing paradox to this. On one hand, the answer is simple: we need to individually and collectively get up. But actually getting ourselves up and moving is incredibly complex. That's because there are so many cues to be seated: whether they're at work, at home, driving here, driving there, going to the cinema. But there are specific approaches that each of us can adopt. In the office environment, there's furniture like the treadmill desk.

Should we all be campaigning for standing desks in our offices?

I don't think standing desks are the magic bullet for reversing the curse of chair addiction, but they're part of the solution. Far more important are things like corporate culture, the way we have meetings, whether walking at lunchtime is encouraged, and so on. If not at work, we need to get up at home as well – we need to have active pursuits with our family and loved ones. Each of us needs to get up from our sedentariness and take a stand on our health.



MORE ON THE PODCAST

Listen to the full interview with James A Levine at sciencefocus.com/podcasts



How To Predict The Unpredictable

The Art Of Outsmarting Almost Everyone

William Poundstone

Oneworld **P** £12.99

LIKE TO THINK of yourself as a bit different from the crowd? Don't fool yourself, says William Poundstone: your behaviour is often pathetically predictable. Still, as that's true for everyone else too, it means you can often second-guess what others are going to do, with winning results.

Poundstone calls on a fascinating array of examples to demonstrate his point. For example, if you're playing the game 'Rock, Paper, Scissors', choose Paper. Studies show that people typically don't choose Scissors, and men actively prefer Rock – which Paper beats. Similarly, when faced with true/false questions and clueless about the answers, pick 'True' – as quiz-setters have a bias towards this response.

Poundstone draws on extensive research to show the roots of our predictability. For example, most of us are hopeless at doing things 'randomly', and we're also over-impressed by amazing performances – both of which can be exploited in, for example, placing bets.

It all makes for a fascinating read. But be warned: these insights may not help much longer now that Poundstone has blabbed them. So read it quick.



ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham



The Tale Of The Duelling Neurosurgeons

Sam Kean

Doubleday **H** £20

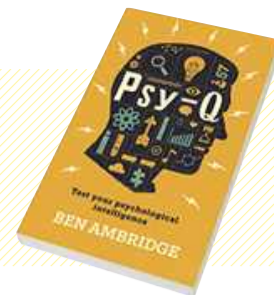
THESE DAYS, YOU can barely go five minutes without some new story about a bizarre new neuroscientific discovery based on advanced MRI scans and the like. So it's perhaps timely that Sam Kean's book takes an eye-opening (and often eye-watering) look at the historical origins of the discipline of the study of the brain.

The book covers several centuries and focuses on some of the fascinating characters who gave rise to the field of neuroscience. With no technology, it was a time when scientists had to rely on the testimony of those suffering brain injury or abnormal behaviour. Kean paints a colourful picture of how our understanding of the brain has come about, from ancient beliefs and bizarre philosophies to modern scientific theories. While the stories he tells are often bizarre and grotesque, Kean remains respectful and light-hearted, rather than mocking or judgemental.

The actual science is relatively basic throughout, so if you're looking for detailed explanations of the brain's workings you may want to try elsewhere. But for an accessible and amusing account of the origins of neuroscience, it's hard to imagine a better book.



DEAN BURNETT is a neuroscientist and author of *The Guardian's* Brain Flapping blog



Psy-Q

Test Your Psychological Intelligence

Ben Ambridge

Profile Books **P** £12.99

EVERYONE KNOWS ABOUT IQ, but what about Psy-Q? According to Ambridge, this is our psychological intelligence – how much we understand what makes us and others tick. You can discover your Psy-Q by completing the tests in this book.

Through puzzles, quizzes, illusions, and jokes, bite-sized information is presented on psychological intelligence – from what current research says to how we can apply it to ourselves. Some of the more familiar tests include Rorschach's inkblot, the Necker Cube, and the Müller-Lyer illusion. More novel tests explore whether you are stupider than a monkey, a conspiracy theorist, or a psychopath.

There are big claims to live up to – that by the end you will have the best answers science can offer. As I completed what Ambridge calls my 'psych-odyssey,' I did have a better understanding of myself. But were they the best answers science can offer? Not particularly.

However, if you don't have a psychology background, *Psy-Q* equips you to become a psychologist for the duration of the book. You will come away with a better understanding of yourself and be encouraged to pursue scientific knowledge.



DR NICOLA DAVIES is a psychologist and health writer



Happiness By Design

Finding Pleasure And Purpose In Everyday Life

Paul Dolan

Allen Lane **H** £20

IN THIS BOOK the behavioural economist Paul Dolan tackles the difficult issue of how we could all be happier. The book is well researched, but hard to buy into in places. Throughout the book Dolan takes a highly individual view of how to be happier and his examples are very functional. For example, he has never read a work of fiction and he argues about whether he would be happier if he did. However, he assumes that we only do things because we consider that they'll make us happier, rather than because they are engaging. This perhaps may be why he downplays social interactions with those we like and love, which psychologists

have argued are central to happiness and wellbeing. For example, we don't care for sick relatives to *make* ourselves happy.

Dolan posits that happiness is a product of pleasure and purposeful activities, which need to be of the right proportion to one another, and to both be there. When it comes to happiness, the argument for 'pleasure' is well supported, but he doesn't always make the case for 'purpose' being important to happiness.



SOPHIE SCOTT is a professor at UCL's Institute of Cognitive Neuroscience

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Fire Tech Camp inspires and empowers young people with awesome digital technology, giving students aged 9-17 the opportunity to get stuck into coding, game design, robotics and making. Their biggest summer programme to date is just ending, with the successful launch of courses in Rapid Prototyping with 3D Printing, 2D and 3D Animation and Digital Music Production, and with new campuses opening up beyond London in Manchester, Bristol and Brighton. Find out more about Fire Tech Camp and what's coming up this October half-term.

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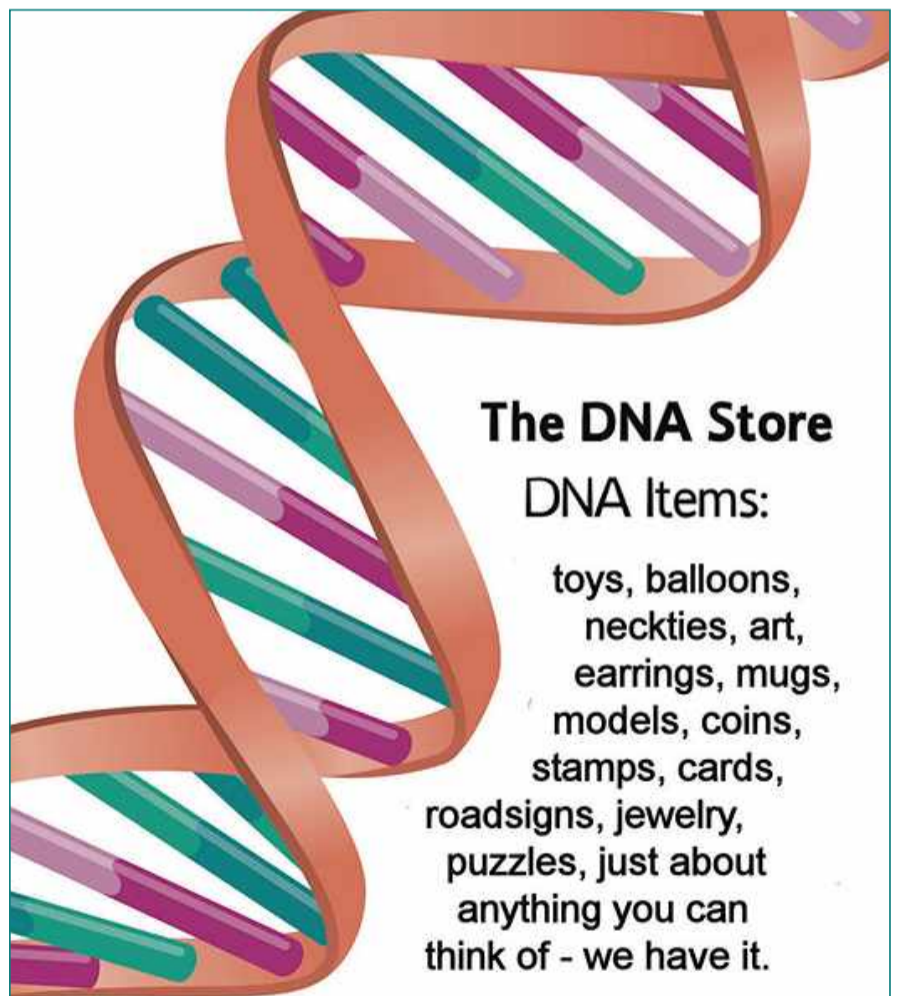
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1 A recent US study claims that people would rather do what than spend time alone with their own thoughts?

- a) Listen to death metal for two hours straight
- b) Drink a beetroot smoothie
- c) Give themselves electric shocks

2 In July, the International Astronomical Union launched an initiative to name which celestial objects?

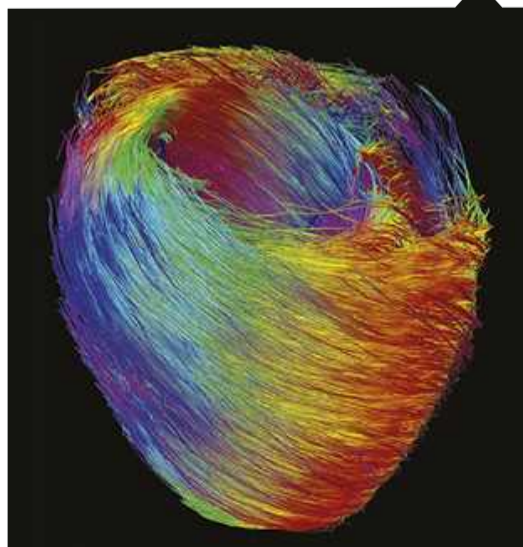
- a) Binary stars
- b) Comets
- c) Exoplanets

3 Complete the recent headline: '_____ is the most polluted place in the world, say scientists'

- a) Oxford Street
- b) Downtown Beijing
- c) Buckingham Palace

4 What is shown in this picture?

- a) An MRI image of a mouse heart
- b) An infrared image of a sparrow's nest
- c) An SEM image of a silk moth cocoon



Scientific research gets psychedelic

5 A fossil of the largest flying bird ever discovered has been identified as a new species. What was its estimated wingspan?

- a) 4.4 metres
- b) 5.4 metres
- c) 6.4 metres



6 Scientists have figured out how a marine animal creates its unique light show. Which one is it?

- a) The mirrorball mussel
- b) The disco clam
- c) The dancing eel

7 Which spacecraft recently celebrated 10 years in orbit around Saturn?

- a) Rosetta
- b) Cassini
- c) Pioneer 10

8 Physicist and *Focus* columnist Robert Matthews has come up with a nifty solution to which common problem?

- a) Not being able to find the end of the sticky tape
- b) Tangled headphones
- c) Inside-out umbrellas

9 Complete the recent headline: 'Early bird *Archaeopteryx* wore _____ for display'

- a) Colourful stones
- b) Purple plumage
- c) Feather trousers

10 A beauty spot on the edge of Mars's Endeavour Crater has been named in honour of which British scientist?

- a) Alan Turing
- b) Colin Pillinger
- c) Peter Higgs

11 Researchers have translated the meanings of chimpanzee gestures. What does it mean when a chimp tears strips from leaves with its teeth?

- a) "Flirt with me"
- b) "I'm hungry"
- c) "Help me build a shelter"

12 British company Surrey NanoSystems has created the world's darkest material. What's it called?

- a) Fantablack
- b) Vantablack
- c) Dantablack

13 This image, one of the Hubble Telescope's most famous photos, shows 'elephant trunks' of interstellar gas and dust in which nebula?

- a) Eagle Nebula
- b) Crab Nebula
- c) Helix Nebula



Clue: it's also known as the 'Pillars Of Creation'

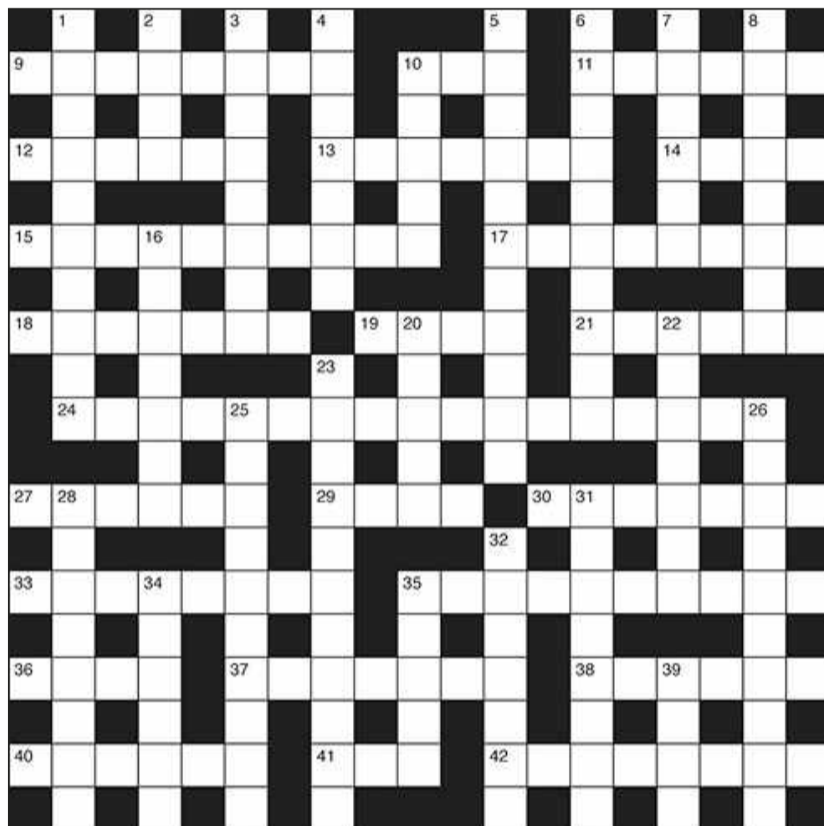
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0-4 IN THE DARK 5-9 DARK HORSE 10-13 DARK KNIGHT

1c, 2c, 3a, 4a, 5c, 6b, 7b, 8b, 9c, 10b, 11a, 12b, 13a

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ACROSS

- 9 Show-biz charity member to drink to traitor (5,3)
 10 Doctor reaches a flightless bird - just too late (3)
 11 Hardly a railway clerk (6)
 12 Mug puts Republican in charge of copper (6)
 13 Terribly dim bit of music at central part (7)
 14 Cover a quiet greeting (4)
 15 See crone panic about solar system (10)
 17 Many sure are affected by dangerous condition (8)
 18 Etiquette about hat turned out to be terminal (7)
 19 Thick mass of stupidity (4)
 21 Woman made ugly by crown (6)
 24 Explorer and king at Buster Keaton film (5,3,9)
 27 Girls wasted energy on young swimmer (6)
 29 Bird having fun (4)
 30 Residence reportedly alright with a tree (4,3)
 33 Graduate exchanges Broads for an island (8)
 35 Wave to military hardware - that shows interference (6,4)
 36 Terribly neat feature of Sicily (4)
 37 I send a canoe round many islands (7)
 38 Space taken by book (6)

- 40 Crazy old chaps find some old stones (6)
 41 Low-flying creature (3)
 42 Detail so different when set apart (8)

DOWN

- 1 Therapist has sodium swirling up throat (10)
 2 The Irish have a descendent (4)
 3 A ranch I'd improve a mite, say (8)
 4 Tolerate an organ (7)
 5 Wireless busy generating waves (11)
 6 Cold-sufferer to pursue law agent (7,3)
 7 Puts back gold in a trance (6)
 8 Caught engineers fixing vase's crack (8)
 10 I'm taken aback as professor finds one in field (3-2)
 16 Arrange the loan, in spirit (7)
 20 Course right for a ship (5)
 22 Car rug obtained from vending machine (7)
 23 Role clothes play - it's insoluble (11)
 25 Concede aspect of elastic limit (5,5)
 26 Genuine but less sensitive to quantity (4,6)
 28 Side effect concerning law suit (8)
 31 Former pupil left four on charge of neglect (8)
 32 Sadly father has one - a problem communicating (7)
 34 Composer nearly gets a Hindu deity (6)
 35 Learn layout of the kidneys (5)
 39 Entangle a forest with foliage (4)

SOLUTION TO CROSSWORD No 165

Alan Pyatt, Peter Haworth, Steve Millard, Alison Hickman and Sue Corbett each solved issue 269's puzzle and receive a copy of *Through The Wormhole Season 4* on DVD (Go Entertain, £14).



WIN! LIFE AFTER PEOPLE SEASONS 1 & 2

The first five correct solutions drawn will each win a copy of *Life After People* (History, £24.99). Entries must be received by 5pm on 18 September 2014. See below for more details.



YOUR DETAILS

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Post entries to *BBC Focus Magazine*, September 2014 Crossword, PO Box 501, Leicester, LE94 0AA or email a scan of the completed crossword or a list of answers to september2014@focuscomps.co.uk by 5pm on 18 September 2014. Entrants must supply name, address and phone number. Immediate Media, publisher of *BBC Focus Magazine*, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' on your email or postal entry if you do not want to receive such information by post or phone. Please write your email address on your postal entry if you would like to receive such information by email.

TERMS & CONDITIONS

Entrants must be UK residents (inc Channel Islands) aged 18 or over. Immediate Media employees are not eligible to enter. By entering participants agree to be bound by these terms and conditions and that their name and county may be released if they win. Only one entry permitted per person. No responsibility is accepted for lost, delayed, ineligible or fraudulent entries. Entries received after the closing date will not be considered. Immediate Media (publisher of *BBC Focus Magazine*) will only ever use personal details for the purposes of administering this competition unless you permit otherwise. Read more about the Immediate

Privacy Policy at www.immediatemediaco.uk/privacy-policy. The winning entrants will be the first correct entries drawn at random after the closing time. The prize and number of winners will be as shown above. The winners will be notified within 30 days of the closing date by post. As Immediate Media's decision is final and no further correspondence relating to the competition will be entered into. If the winner cannot be contacted within one month of the closing date, Immediate Media reserves the right to offer the prize to a runner-up.

HOLLYWOOD SCIENCE

Separating science fact from movie fiction

Amnesia in **BEFORE I GO TO SLEEP**

THIS MONTH, *BEFORE I Go To Sleep* hits the big screen with Nicole Kidman starring as Christine, a woman who suffers a traumatic event then wakes each morning to find she's forgotten what happened the day before. If the plot seems familiar it's because it is. Drew Barrymore's character suffered a similar fate in the 2004 film *Fifty First Dates*. *Before I Go To Sleep* is the latest in a long line of movies to feature amnesia. But memory loss is complicated, and Hollywood very often gets it wrong.

There are many different types of memory loss. Sometimes sufferers of anterograde amnesia can hold a conversation and then forget they've had it a few minutes later. In retrograde amnesia, memories from much further back are obliterated. Christine has both types. "It makes a very useful plot device,"

"Memory loss is complicated, and Hollywood often gets it wrong"

says memory researcher John Aggleton from Cardiff University, but Christine is unusual because her memories are erased as she sleeps. "It doesn't make sense. There's no evidence that sleep damages memory," says Aggleton.

The closest, undisputed condition to Christine's is one called long-term amnesia. Described in the '90s and very rare, sufferers forget new information over days and weeks rather than overnight. Then in 2010, psychologist Larry Squire from the University of California, San Diego, described the world's first case of a person whose daily memories were erased by sleep.

Known by her initials, FL, she succumbed to her fate after a car crash in 2005. But her symptoms are unusual. People with amnesia can still learn and perform new motor skills, such as tracing the reflection of a shape in a mirror, but forget that they know them. FL doesn't learn at all. And she can be tricked into remembering something from the previous day if it's done covertly. Squire thinks she suffers from an unusual form of so-called

functional amnesia, where there is no structural brain damage but the symptoms are genuine.

Aggleton is not convinced. "The literature of functional amnesia is littered with people who are not amnesic," he says. FL also claims never to have watched *Fifty First Dates* before her accident, yet Barrymore is one of her favourite actors, leading to further scepticism of her condition. What's more she's now returned to work, "which is very impressive if she forgets what she does every day. The whole thing is very curious," says Aggleton.

In the spirit of Hollywood, however, FL's story has a happy ending. Her memory was found to improve when she woke up every four hours during the night. If FL turns out to have a new disorder, maybe Hollywood got it right. ■



HELEN PILCHER is a science writer and comedian. She tweets from @Helenpilcher1





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